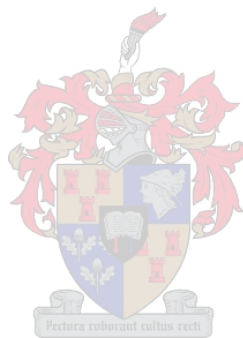


# **The development and testing of a Computer Aided Instructional Resource for the teaching of Physical Science**

**K.C. van Zyl**



# **The development and testing of a Computer Aided Instructional Resource for the teaching of Physical Science**

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B.Sc., M.Ed.**

**Dissertation presented for the Degree of Doctor of  
Philosophy at the University of Stellenbosch.  
Promoter: Dr A.S. Jordaan**



**Promoter: Dr. A.S. Jordaan  
Co-promoter : Dr. P. van der Westhuizen**

**December 2004**

# Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature : \_\_\_\_\_

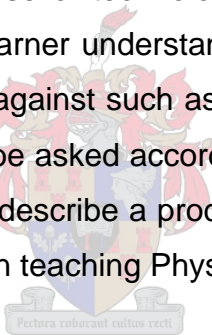
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## Summary

This study set out to develop and test a Computer Aided Instructional Resource for Physical Science in Grades 11 and 12. The software was tested in the context of Newtonian Mechanics. This study differed from most other studies in that it did not develop or test tutoring-type software that the learner uses on a one to one basis in a computer laboratory. It did, however, test and develop software to be used by the teacher in the classroom while teaching.

A theoretical framework is presented, built on experience-based as well as literature-based theory. In this framework, the effects of computer interventions on the teaching and learning situation as reported in the literature are viewed within the South African context. In the light of what is reported in the literature, the education authorities' attempts to disseminate the curriculum with the use of technology, are questioned. Reasons for not doing a quantitative assessment of learner understanding of concepts are presented with reference to criticism in the literature against such assessments. The dissertation reports on the type of questions that need to be asked according to the literature. This discussion then leads to research questions that describe a process for the developing and testing of a resource that could assist teachers in teaching Physical Science.



Developmental methods as well as ways of assessing had to be researched to determine the best way in which such a resource could be developed and tested. During this research it was found that the implementation of Information and Communication Technology (ICT) to deliver the curriculum had focused more on the development of tutoring type software and it seemed that the use of computers for actual classroom instruction did not receive as much attention. It was however possible to identify developmental and assessment principles that were common to research that had been done and the project that is reported in this dissertation.

The Computer Aided Instructional Resource (CAIR) was developed by the researcher in the form of a presentations package that the teacher could use in the classroom while teaching. It was tested in a Prototyping Stage in the researcher's classroom before being tested in eight project schools during the Piloting Stage. This was done by connecting personal computers up to 74cm televisions and then displaying the CAIR on the TV while

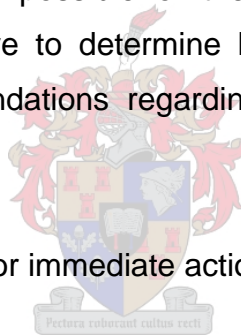
teaching. This was made possible by TRAC South Africa that funded the project. It also provided an opportunity to assess the use of the TRAC system in the same schools.

After assessment criteria had been identified, assessment instruments were developed to assess the project in different ways. There were questionnaires for each stage to be completed by learners and teachers as well as an observation instrument that was used by the researcher during classroom visits. These assessment instruments made it possible to assess the CAIR with respect to didactical, visual and technical considerations.

Results of the empirical study are presented under the assessment criteria that had been identified and are discussed with reference to the original research questions.

The results of the assessment were very positive for both the CAIR and TRAC systems. The study has however tried to focus on the negative rather than positive outcomes to present as unbiased a picture as possible of the assessment results. It was also necessary to focus on the negative to determine how and where the CAIR could be improved and, to make recommendations regarding the implementation of the TRAC system.

Recommendations are also made for immediate action and further investigations.



## Opsomming

Hierdie studie het gepoog om a rekenaar gesteunde onderrighulpmiddel te ontwikkel en te toets. Die sagteware is ontwikkel en getoets in die konteks van die onderrig van meganika. Die studie verskil van die meeste ander studies daarin dat die sagteware nie ontwikkel is vir die gebruik van leerders in 'n een-tot-een situasie in 'n rekenaar laboratorium nie. Die sagteware is eerder ontwikkel om deur die onderwyser gebruik te word terwyl onderrig in die klaskamer plaasvind.

'n Teoretiese raamwerk wat op ondervinding en literatuurnavorsing gebou is, word aangebied. In hierdie raamwerk word die effek wat rekenaarintervensies op die onderrig-leer situasie het, soos in die literatuur vermeld, binne die Suid Afrikaanse konteks geplaas. Die opvoedkundige owerhede se pogings om die kurrikulum te versprei met behulp van tegnologie, word bevraagteken na aanleiding van inligting wat in die literatuur verkry is. Redes waarom 'n kwantitatiewe evaluering van leerderbegrip van konsepte nie gedoen is nie, word aangebied met verwysing na kritiek teen sulke evaluerings vanuit die literatuur. Vrae wat volgens die literatuur wel gevra moet word, word gerapporteer. Hierdie bespreking lei na die navorsingsvrae wat 'n proses beskryf vir die ontwikkeling en toetsing van 'n hulpmiddel wat onderwysers van nut kan wees in die onderrig van Natuur en Skeikunde.

Ontwikkelingsmetodes sowel as kwalitatiewe evaluering is nagevors om die beste metodes vir ontwikkeling en toetsing te bepaal. Daar is gevind dat die implementering van Inligting en Kommunikasie Tegnologie om die kurrikulum oor te dra, meer op tutorial-tipe sagteware gefokus het. Die gebruik van rekenaars vir klaskamerinstruksie het nie soveel aandag in die literatuur geniet nie. Dit was egter moontlik om beginsels vir ontwikkeling en toetsing te identifiseer wat in ander studies gebruik is en wat hier ook toegepas kon word.

Die hulpmiddel is ontwikkel in die form van 'n aanbiedingspakket wat die onderwyser in die klaskamer kan gebruik terwyl hy of sy onderrig gee. Die prototype is in die navorser se klaskamer getoets voordat dit in agt projekskole in 'n loodsprogram getoets is. Dit is gedoen deur 'n persoonlike rekenaar in elke klaskamer aan 'n 74cm televisie te koppel.

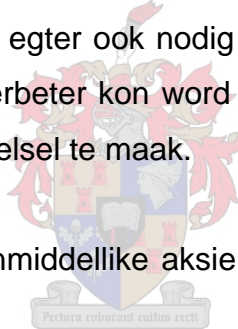
Dit is moontlik gemaak deur TRAC Suid-Afrika wat befondsing vir die projek verskaf het. Dit het ook 'n geleentheid verskaf om 'n kwalitatiewe evaluering van die TRAC stelsel in dieselfde skole te doen.

Nadat evalueringskriteria geïdentifiseer is, is meetinstrumente ontwikkel om die projek op verskillende maniere te toets. Vraelyste moes in elke fase deur leerders en onderwysers voltooi word. Daar was ook 'n instrument vir gebruik deur die navorser tydens klasbesoek. Die hulpmiddel kon sodoende getoets word in terme van didaktiese, visuele en tegniese aspekte.

Die resultate van die empiriese studie word aangebied onder die evalueringskriteria en word bespreek met verwysing na die oorspronklike navorsingsvrae.

Die resultate was baie positief vir beide die onderrighulpmiddel en die TRAC stelsel. In die studie is gepoog om resultate so neutral moontlik aan te bied deur eerder op die negatiewe te konsentreer. Dit was egter ook nodig om op die negatiewe te konsentreer om te bepaal hoe die hulpmiddel verbeter kon word en om aanbevelings ten opsigte van die implementering van die TRAC stelsel te maak.

Aanbevelings is ook gemaak oor onmiddellike aksie wat geneem kan word, sowel as vir moontlike verdere ondersoek.



# Thanks

I would like to extend my sincere thanks to the following people:

- Dr A.S. Jordaan for his role as promoter, his support, much needed assistance and his role as mediator in conflict situations.
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*Dedicated to Irma. Thank you for all your support and for being a willing ear.*



Kevin Clive van Zyl

December 2004



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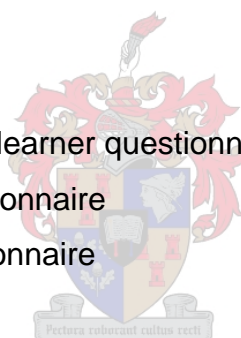
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# Chapter 1

## INTRODUCTORY BACKGROUND TO THE STUDY

### 1.1 Introduction to the chapter

In this study a Computer-Aided Instructional Resource (CAIR hereafter) for teaching mechanics was developed and tested in Grade 11 and Grade 12 in nine schools. The study was executed in conjunction with the TRAC project.

For the purpose of this study a CAIR is defined as a multimedia presentation resource used by the teacher in the classroom. It was developed to function similarly to presentation packages like Microsoft's PowerPoint. One of the main challenges in developing the CAIR was designing it to be disseminated via the Internet. To accomplish this, the CAIR was developed using Internet-friendly technology that makes viewing of images, animations and text easy with the use of web browsers. This also ensured small file sizes to limit download times over the Internet.

The TRAC project supplies computerised interventions to assist science teachers. The system uses detectors and probes connected to a computer to produce data for analysis. TRAC also supplies worksheets that assist learners to conduct practical investigations. These worksheets help learners to prepare for and execute practicals and can be used as a resource when preparing for examinations.

This chapter is aimed at enabling the reader to appreciate and understand my assumption that the development and testing of a CAIR were worthwhile pursuing in a research study. According to Cline (2003) this helps to establish ... *a vantage point, a perspective, a set of lenses through which the researcher views the problem*. This assumption needs to be considered within a number of contexts. The following contexts will be discussed in the next section.

- the current situation in science education in South Africa and the possible effects of future developments;

- my personal experience of multimedia implementation, literature reports on the effects of multimedia and the choice of TRAC as a partner in this study;
- attempts by education authorities and others to disseminate the curriculum through technology with projects like the Khanya project viewed in the light of literature reports on the effects of computer interventions on the teaching and learning situation;
- the effects of gender, language and socio-economic standing on attitudes towards computers.

The discussion of these contexts provides a theoretical framework that also serves as a demarcation of the topic by the author. It informs the reader what is being investigated and why the investigation does not take another route. In their guidelines for research papers the Faculty of Public Administration at the University of Oklahoma (2004: 2) puts it as follows ... *the author determines the topic and can only be criticized on issues internal to his own demarcation of the topic.*

The discussion that establishes the theoretical framework in section 1.2 goes beyond a literature review. Camp (2001: 15) warns that a theoretical framework cannot be provided by a literature study alone and refers to Marshall and Rossman (*ibid.* 2001: 11), who state that theoretical frameworks are built on experience-based theory as well as literature-based theory. Camp (2001: 12) concludes that, besides presenting the theoretical assumptions, the researcher must show how these assumptions lead to the purpose, objectives or questions of the study. The discussion in section 1.2 does not only serve to contextualise my assumptions in terms of experience or literature-based theory, but it also serves as a theoretical framework that leads to the definition of relevant research questions.

The chapter is concluded with an overview of the relationship between the different chapters in the dissertation to present a coherent argument.

## 1.2 Motivation for the study

### 1.2.1 The situation in science education in South Africa and possible future developments

South Africa is in need of Scientists. Professor Kader Asmal was quoted in *The Sunday Times Insight* of 5 August 2001 as addressing this need as follows:

*The number of young people who study mathematics with any degree of understanding and proficiency has declined when it should have been increasing rapidly ... as a result the pool of recruits for further and higher education in the information and science-based professions is shrinking. This has grave implications for our national future in the 21<sup>st</sup> century.*

I have experienced at my own school that private companies that require engineers, computer scientists, chemists and physicists are targeting schools again to find talented students in the hope of offering them full scholarships. Dr David Potter, chairman and founder of Psion Computers in the UK, presented a lecture organised by Prof. Kader Asmal on 20 June 2000 at Pentech in Bellville. His lecture focused on the significance of higher education in South Africa in preparing scientists for the role that needs to be played in the global economy. When asked by a member of the audience how this could be done in South Africa, where there is a decline in admissions to tertiary institutions, Dr Potter replied he could not offer any real solutions, but that the expertise for such a solution is available in South Africa. One possible solution could be to target secondary schools in recruiting students for higher education.

While having to address these real needs in the South African context, the majority of our schools have under-equipped facilities and under-qualified teachers. Buirski-Burger & Sewell (1998) emphasise this problem:

*The essence of the problem is that very few people with appropriate science qualifications become teachers and thus the teaching of science is left to people who themselves are struggling with the ideas. In this situation the move to OBE could cause a further substantial degradation of science education. Preventing the degradation will ultimately require teacher certification - this in its turn will require the systematic retraining of teachers - something that is unlikely at present.*

Mangena (2001) stated that the Mathematics and Science Audit of 1999 found that 68% of science teachers had no formal subject training. He also quoted the Edusource report of 1997, pointing out that 74% of all science classes had more than 40 learners per teacher; 84% of science educators had a professional qualification, but only 42% were qualified in science and 40% of Physical Science teachers had less than two years experience.

Mangena also mentioned that few learners who graduated in Science chose teaching as a career and that this leads to a vicious cycle of under-supply of Science teachers. 8200 Science teachers had to be targeted to address the lack of subject knowledge. Mangena's reference to ... *a lack of facilities and resources to enhance effective learning and teaching* is supported by a report in the *Sunday Times* (5 August 2001), noting that in 22 education districts, only 430 out of 2593 schools had laboratories. One Mathematics and Science expert has to support teachers in up to 360 schools.

Grayson (2001) also addressed the lack of subject knowledge in teachers. She emphasised that teachers need long-term professional development and warned that it will take a number of years before teachers develop the required understanding and skills. She points out that ... *While this process is under way, something else must be done to help the current cohort of pupils get a good Maths and Science education.*

In responding to Dr Potter's lecture Mrs Joan Joffé, chairperson of Vodacom Foundation, supported the view that the private sector needs to be involved in finding real solutions to the problems that we face in Science education.

In the past fifteen years I have experienced at first-hand how inadequate innovations in education have meant that the so-called expertise and knowledge of educational experts became questionable when the initiatives fail a few years down the line. The most recent and probably most publicised example of this was the non-implementation of Curriculum 2005. These experiences could be seen as a warning of what not to do if private sector investment is sought. Initiatives in education that start at Grade 1 level should probably only be implemented after the process has been properly thought through for both the General Education and Training (GET) and the Further Education and Training (FET) band.

Ogunniyi (1986, cited in Van der Linde, Van der Wal & Wilkinson 1994: 49) stresses that, despite curriculum innovations in Science education, progress is hampered by various critical issues. These include poor teacher preparation, a shortage of qualified teachers and the use of archaic teaching methods. Khan (1987, cited in Van der Linde *et al.* 1994: 49) refers to the *dull and uninteresting way in which subject matter is presented*. Van der Linde *et al.* (1994: 49) also mention the *neglect in conditions that stimulate pupils' interest in Science*.

Van der Linde *et al.* (1994: 50) address the issue of teacher training. They remark that many teachers are not trained in Physical Science above the level at which they are teaching. They suggest (*Ibid.* 1994: 51) that computer simulation is one of the technologies that can be used to make the world of Science more exciting. Mehl (1991: 14) remarks that ... *we need to realise that, given the great educational imbalances in this country, computer-based education not only supplies us with real hope, but also the very real opportunity to do it right*.

One may rightfully ask how the current state of affairs as reported above relates to imminent as well as possible future developments. The first change to contemplate is the planned introduction of the new curriculum in Grade 10 in 2006.

Although Grayson (2001) applauds features such as learner-centred approaches and outcomes-based education in the new curriculum, she has warned that a ... *Science teacher who lacks adequate content knowledge will feel unable to run learner-centred classes for fear of having his own deficiencies exposed*. She also states that one cannot only focus on how learning takes place, but that sufficient focus on content is needed.

The new curriculum demands many other skills from its teachers as well. This becomes evident when studying the National Curriculum Statement for Physical Sciences. Teachers will need to marry content with learning outcomes, thrusts described under the learning outcomes, assessment standards, competency descriptors and assessment methods incorporating criteria-referenced assessment (e.g. rubrics) with level descriptors for achievement. This must seem rather daunting to a teacher who does not even have a firm grasp of the content.

Unfortunately the new curriculum has not managed to fully incorporate some of the more profound approaches in science teaching. An example of one such approach has been under development at Arizona State University. This approach is called modelling. Wells, Hestenes & Swackhamer (1995: 611) describe a teaching methodology in which learners are part of the process of model development. This means that learners need to understand more than the relationship between quantities as described in laws or definitions. They also need to understand how these models are developed and themselves become developers of models. They therefore learn the skills of defining concepts and formulating laws. In this way they gain an appreciation of the nature of scientific enquiry. This approach reminds one of the words of John von Neumann (in Gleick 1997: 273):

*The sciences do not try to explain, they hardly even try to interpret, they mainly make models. By a model is meant a mathematical construct which, with the addition of certain verbal interpretations, describes observed phenomena. The justification of such a mathematical construct is solely and precisely that it is expected to work.*

The assessment guidelines for C2005 for Natural Science (Department of Education 2002a: 30) in the GET phase describes the rationale for Natural Science (of which Physical Science is a component) as follows:

*The development of appropriate skills, knowledge and attitudes and an understanding of the principles and processes of the Natural Sciences should*

- *enable learners to make sense of the world*
- *contribute to the development of responsible, sensitive and scientific literate citizens who can debate scientific issues and participate in an informed way in democratic decision-making processes*
- *emphasise the importance of conserving, managing, developing and utilising natural resources to ensure the survival of local and global environments*
- *contribute to the creation and shaping of work opportunities.*



It adds that:

*Natural Science is about investigating, exploring, doing Science and being practically involved in discovering about Science.*

Unfortunately this description does not help us at all to gain any understanding of governments' position on the nature of science. The term Natural Science in the above description can be replaced by the word Economics and would still make sense without distinguishing between the two areas at all. The nine specific outcomes also fail to address this issue as they can be grouped under three headings namely, Scientific Processes, Scientific Knowledge, and Science and Society. The only place where the nature of Science is mentioned is in Specific Outcome 7, where it refers to "Contested nature" (indigenous knowledge).

The revised National Curriculum Statement (Department of Education 2002b: 22) addresses the issue a little better under its definition of Natural Sciences. In this document the *McGraw-Hill Concise Encyclopaedia of Science and Technology*, 2<sup>nd</sup> Edition, p. 1647 is quoted as follows:

*... It (science) has been shaped by the search to understand the natural world through observation, codifying and testing ideas and has evolved to become part of the cultural heritage of all nations. It is usually characterised by the possibility of making precise statements which are susceptible of some sort of check or proof.*

It adds that:

*Meaningful education has to be learner-centred. It has to help learners understand not only scientific knowledge and how it is produced but also the environmental and global issues.*

This is the first time that an official document has hinted at the nature of Science as a modelling process as described by von Neumann and interpreted by Wells, Hestenes & Swackhamer (see p.6). It clearly sees Science as more than just a body of knowledge or an investigative process. It recognises that the quest of Science is to understand natural



phenomena by making models that are then rigorously tested for the sake of improving those models (*Codifying and testing ideas* (see p. 7)). It also recognises that learners should be helped to understand how this knowledge is acquired.

When one turns to the learning outcomes that have been formulated, it becomes clear that the NCS has failed to recognise this important aspect of the nature of Science. The nine specific outcomes of C2005 have now been reduced to three learning outcomes (Department of Education 2002b: 23). Although these outcomes do focus on scientific investigation and constructing scientific knowledge, they do not specify that learners need to acquire skills in scientific modelling. They only seem to expect learners to know, apply and interpret knowledge. Although the issue could be addressed under the outcome that deals with Science and Society, this calls for some insightful interpretation that was most likely not intended. It therefore seems that government has failed to identify modelling skills as an important aspect that needs to be facilitated in the teaching of Natural Science. It therefore seems to fail in exactly the same way that all previous curricula have failed.

Although more emphasis is being placed on scientific investigation in the NCS, one has to realise that the method of scientific investigation is merely a tool used by scientists to construct or test models. The method is also used in conjunction with scientific models in applied sciences and technological applications and processes. However, this same method is used by researchers in many different fields, not only in Science. It seems that the curriculum could run the risk of reducing a learner's understanding of Science to being an investigative method that either verifies old knowledge or uses knowledge to solve problems or investigate phenomena. The statements of the outcomes do not convey a realization that such investigation leads only to a model of the phenomenon under investigation.

The oversights in curriculum development as discussed above possibly (and hopefully) means that we can expect some changes as curriculum developers become aware of their oversights. The downside of this is that teachers will need to cope with changing expectations communicated through amended curricula. The process of continuous change may be inevitable and it would therefore seem appropriate to try and develop resources that would help teachers to deal with this process of change. Resources that could help deliver content to the classroom in a format that is appropriate to the

acceptable teaching approach of the time could help teachers immensely as a time-saving device and could possibly assist in structuring lessons.

I believe that the development and implementation of CAIRs in science classrooms could be one way to respond to Grayson's (2001) call that something else must be done while teachers are enrolled in professional development programmes. This view that multimedia resources can make a difference in the classroom is shared by a number of other authors and will be discussed in section 1.2.2. I also believe that the low development cost and possibility of delivering CAIRs easily via the Internet make it a useful resource to help implement possible future changes (e.g. modelling approaches) more expediently. These technical features of CAIRs receive more attention in Chapter 4.

The beliefs/assumptions mentioned above need to be tested by determining whether CAIRs are well received by teachers and learners, and whether teachers and learners report that implementation of CAIRs has contributed positively to the classroom situation.

### **1.2.2 My personal experience of multimedia implementation, literature reports on the effects of multimedia, and the choice of TRAC as a partner in this study**

Section 1.2.1 made a connection between my assumptions, some of the problems currently experienced in science education and possible future developments. This section explores the choice of a CAIR as the type of computer intervention to be developed and tested.

Viewed against the background of the previous discussion, this project endeavoured to set a process in motion to develop and test a resource to be implemented in Science classrooms. It was envisaged that the resource would guide and support both the student and under-qualified teacher. The same resource should also be valuable to the experienced teacher. It should serve to provide a teaching programme and alleviate the teacher's efforts of having to deal with resource development and shift the focus towards dealing with students. The final product would be a computer-based presentation resource that would be used on a daily basis in the classroom.

Why a computer-based system? The answer to this question lies partly in the nature of my own teaching experience. I have been using a PowerPoint-based presentation resource at a private school in Cape Town since 1998. I found that the system saved time

in class and helped me in structuring lessons. It also made it possible to have a visual presentation resource that could be made interactive for both instruction in the classroom and for use by students. The flow of information could be controlled and adapted to the needs of a specific class.

My positive experience is also echoed in some of the literature. Luna and McKenzie (1997: 1) reported a 79% response from faculty members believing that multimedia increased classroom performance and also noted that 86% believed that student retention was increased. Weinraub (1998, cited in Carter 1995: 5), found an improvement in student perceptions and attention spans when multimedia presentation software was utilized. The study also found a positive effect on students' perceptions of the instructor's teaching ability. Zhang (2002) also showed that students in multimedia classrooms had better perceptions of their instructor's instructional methods. Goldsborough (1999) cites a University of Minnesota study that claims a 43% increase in the chance that an audience will accept your position when you use visual aids. He also refers to studies at Harvard University and Columbia University claiming an increase in retention of up to 38%. These studies also found that students had positive attitudes towards multimedia classrooms. Tait (2001) concluded that PowerPoint could offer effective, organized delivery and that it may have a moderate impact on student learning and interest without having any negative effect on either student attitude or classroom atmosphere. In the South African context Dr Mamphela Ramphele, MD of human development at the World Bank (cited in South Africa's official Internet Gateway 2003), said that ... *The teaching of Maths, Science and English using multimedia approaches ... will go a long way to building strong foundations for the futures of these young people.* Dr Ramphele made this remark in an interview about the Mindset Network. This network aims to address some of the challenges in the South African education system through the provision of learning materials in broadcast, print and the Internet. Salvi (2002: 2) mentions, however, that research is needed to prove that all the effort and money being put into multimedia is worth it.

At this point it is necessary to define the term multimedia for this study. Havice (1999: 52) mentions that there is some confusion between the terms multimedia, hypertext, hypermedia and integrated media. In this study the term multimedia means that the presentation resource can make use of text, images, animations or even video and sound in the same application.

In similar vein to Salvi, Havice (1999: 54) calls for studies to address the effectiveness of integrated media presentations by looking at issues such as cost effectiveness, the use of various instructional media for different types of subject matter, different types of students and different instructional methods. Mayer and Coleman (2000: 2) express the need for systematic data on the following basic questions:

*...What do students think about technology? How do they assess the effectiveness of technology as an aid to learning? How do their behaviours and assessments depend on different instructors and teaching strategies? Does the use of technologies affect the content, presentation, and organization of lectures and other course materials? How does it help or hinder a teacher's ability to provide effective instruction?*

The literature does, however, not only report positively on the use of presentation media. Some authors have presented both advantages and disadvantages to using presentation software. Bostock focuses on clarity, structured chunks, ease of development and modification, and handouts that are copies of the projected information as advantages. As disadvantages he mentions boring content that all looks the same, learning to use it can be hard, some ready-made designs are too complex and print badly, and drawings are time-consuming to make. Mayer and Coleman (2000: 3) reported that multimedia presentations improved the flow and clarity of their lectures and that the use of this medium made it possible to easily incorporate graphs, charts, movies and sound. Just like Bostock, they also refer to the time needed for development as a disadvantage. They also point out that there are technical difficulties such as getting the lighting just right. A further disadvantage is that students tend simply to copy information down for fear of not having it later. This problem was addressed by making the slide shows available for download and printing off the Internet. Despite mentioning these disadvantages, Mayer and Coleman (2000: 6) reported an overwhelmingly positive response from the students. They report that students found classes more interesting, note taking simpler, and learning course material easier. Bartsch and Cobern (2003: 86) concluded from their study that PowerPoint could be useful, but that ... *material not pertinent to the presentation can be harmful to students' learning.*

Sammons (1995: 2) reported three significant responses from students with regard to computer-aided presentations. The first was that presentations made the class organized

and supported content. Learners noted as the second most important feature that presentations made lessons more interesting and that they helped with understanding material. The third most important response was that presentations helped them pay attention and clarified information. 80,1% of their students felt that they should continue using computer-aided presentations. Learners also noted seven other benefits of computer-aided presentations (*ibid.* 1995: 3): made information neater and more colourful, aided note taking, helped students to remain focused, aided visual learning, provided a more flexible and efficient way of teaching, helped with reinforcement, showed that lecturers were keeping up with technology. The negatives were also listed. These could be summarised under five different points:

- Learners pointed out several issues surrounding Screen Design. These included letters that were too small, not enough contrast in colour, too much information on the screen and an absence of an outline with a hierarchy of points;
- On the issue of multimedia, some students felt the technology was under-utilised and they wanted more animation, pictures, diagrams and maps. Some felt that transition effects like flying text should be minimised;
- Regarding teaching methodology, some complained that lecturers went too fast and that points were simply read off and not integrated into the structure of the lesson. They also felt that they needed more time to take notes;
- With regard to room design and layout, students felt rooms were too dark and there was a request for larger screens;
- As far as hardware was concerned, they wanted faster systems.

It would seem that there is support in the literature for the idea that the use of multimedia presentations could help with content dissemination, but that some issues needed attention and that some questions needed answering. These questions relate to appropriate presentation design as well as the reaction of learners to the intervention. This study acknowledges these issues in the formulation of its research questions (see p. 29).

There were several reasons for choosing TRAC as a partner in this project. TRAC was already using stand-alone computers to support instruction with practical investigation. TRAC researchers had, however, expressed interest in developing a virtual laboratory that would not need the use of probes. If there were enough indications that CAIRs could be

useful resources, it might be worth TRAC's while to integrate CAIRs and a virtual laboratory into a single package. It therefore seemed to be a good opportunity to also gain some insights into how the TRAC intervention was received by the schools. The fact that TRAC schools already had computers would also mean a considerable cost saving to the project.

### **1.2.3 Attempts by education authorities and others to disseminate the curriculum through technology with projects like the Khanya project viewed in the light of literature reports on the effects of computer interventions on the teaching and learning situation**

Section 1.2.2 sheds light on why I chose to investigate the development and implementation of a multimedia presentation resource and why I chose TRAC as a partner. It does not, however, offer any insights into why I did not rather choose to investigate another use of computers, e.g. the effect of computer-assisted tutoring programs, to try and relieve the plight of the South African Science teachers.

A researcher in the Western Cape may be tempted to follow the route of investigating the effects that more learner-centred interventions (by learner centred is meant an intervention where learners themselves use the computers and where software is designed to facilitate individual needs) have on learning, for the following two reasons. The first is that many studies that have investigated the effect of learner-centred-type interventions on learning are reported in the literature. The results from these studies and the research methods used in them could easily form part of a framework for a new study. The second reason is that the educational authority in the Western Cape Province, where I am based, has embarked on projects to install computer networks into schools to attempt the technological delivery of the curriculum. An investigation into learner-centred-type interventions could therefore contribute to such ventures by supplying both software and expertise about the effect of such interventions.

I have reservations about the feasibility and value of the type of endeavours and studies described in the previous paragraph. This section will explore these points of view by respectively addressing each of the two reasons posed in the previous paragraph.



### 1.2.3.1 The effect of learner-centred-type interventions

The effect that learner-centred interventions have had on learning as reported in the literature needs to be viewed in the context of the type of computer interventions that have also been reported in the literature. This section therefore starts by briefly relating different types of computer use as classified in the literature. This also helps the reader to appreciate the difference between the types of intervention suggested in this study and the types that have been reported in the literature.

A literature search has shown that different authors have classified computer use in education in different ways. Reeves (1998:2) refers to two uses. The first is the use of computers for tutorial-type purposes and the second sees the computer as a tool for presentations or word processing or data manipulation. Fiolhaus and Trindade (1998) identify simulations, multimedia, telematics, virtual reality and computer-based labs. Perkins (1992 cited in Means and Love 1999: 1) mentions that computers can be used as an instructional resource, a learning tool or a storage device. Valdez, McNabb, Foertsch, Anderson, Hawkes and Raack (2000) prefer to look at computer use in education by focusing on the different phases through which computer use has evolved. They identify three phases and label them in succession as print automation, expansion of learning opportunities and data-driven virtual learning.

Valdez *et al.* (2000) explain the transition from one phase to the next as follows. During phase one behavioural-based branching software that relied on drill and practice types exercises was used. During phase two the use of computers moved away from content delivery and became tools for learner-centred practices that involved working in groups. In phase three data-driven decision making activities were introduced.

In the descriptions given above, the focus of computer use seems often to be on the learner and not the teacher as the user. In this study, where the focus is on the teacher as user, the term multimedia is used to describe the richness of the media in a presentation resource and not in a tutoring-type programme. However, in the literature the term multimedia is more often used to describe media-rich tutoring-type programmes. Ellis (2001: 2) uses the term multimedia to describe an animation-rich interactive tutorial. Valdez *et al.* (2000) also describe learner-centred multimedia activities in their account of phase 2 activities. Similarly Means and Love (1999: 1) describe Grabinger's Rich Environment for Active Learning (REAL) as authentic learning contexts in information-rich

environments used by learners that promote high-level thinking processes. It is important that the reader remembers that the effect of multimedia on learning in the remainder of this section refers to multimedia in programmes used by the learner.

Now that the different uses of computers have been highlighted, one needs to ask if the use of computers has made a significant difference to learning. On this issue there seems to be some disagreement. A number of authors quoted in Buirski-Burger & Sewell (1998, including Kulik 1994, Fletcher *et al.* 1990, Pea *et al.* 1995 and Nakleh 1994) have reported on the successes of computers in the learning process. These authors report that learners usually learn more quickly and enjoy the classes more. They also mention benefits like decreased tedium and enhanced understanding. Means and Love (1999: 10) claim that constructivism (a learning theory that assumes that we construct our own understanding of our world from past experiences) forms the philosophical foundation for the re-design of educational technology. This could be the reason why many of the interventions that are designed are learner centred. However, Hannafin and Savenye (1993 cited in Havice 1999: 54) blame the failure of the early use of technology in education on reformers underestimating the importance of the teacher.

Clark (1994: 26) has argued that it is not the media that influence learning. In his words: *learning is caused by the instructional methods embedded in the media presentation.* Clark argued (*ibid.* 1994: 22) that if it was possible to obtain similar learning gains with another set of media, then the gains could not be attributed to the media. The learning gains could be the result of some uncontrolled shared property that is prevalent in both approaches. Kozma (1994: 16) has, however, presented arguments that oppose Clark's point of view. He has argued that media and methods are both part of instructional design and that *Media must be designed to give us powerful new methods, and our methods must take appropriate advantage of media's capabilities.* Joy (1998: 20) reports that experimental media comparison research has been dominated by findings of no significant difference and attributes this result to design flaws and uncontrolled variables other than the media itself. After his discussion of descriptive research, Joy concludes that (1998: 25)

*... there are a wide variety of variables that can explain academic achievement. Attempts to isolate any one variable such as delivery mode in an empirical study in order to prove causation have been difficult for most*



*researchers to do and seldom produced any significant conclusion. Conversely, if truly significant differences were to be found in a properly designed experiment, their usefulness would be very limited because of the extent of artificial controls required to produce such a result.*

Although Ellis (2001: 4) reports that a tutorial enhanced with animations produced an improvement in adult students' ability to apply knowledge (provided that terms like multimedia and learning are narrowly defined in such studies) and Valdez *et al.* (2000) found that computer-based technology enhanced student achievement, the significance of these improvements and enhancements become questionable when viewing the results of meta-analyses that have examined the effect of technology on learner outcomes.

Waxman, Connell and Gray (2002) report on a number of meta-analyses during the past three decades. They quote studies by Blok, Oostdam, Otter and Overmaat (2002), Kulik and Kulik (1991) and Ouyang (1993), who examined the effects of computer-assisted instruction and found it to have positive but small effects. Hattie (1999) supports these findings by averaging the effect sizes across 557 meta-analysis studies that investigated effects of introducing computers on students' achievement. To explain the interpretation of effect sizes, Hattie quotes Cohen (1977), stating *... that an effect size of 1,0 would be regarded as large, blatantly obvious, grossly perceptible, and he provided examples such as the difference between mean IQ of PhD graduates and high school students (we hope).* The average effect size across the 557 studies was 0,31. Hattie explains that *...an effect-size of .31 would not according to Cohen (1977), be perceptible to the naked observational eye, and would be approximately equivalent to the difference between the height of a 5'11" and a 6'0" person.*

Hattie (*ibid.*) argues that *... we must not compare having computers to not having computers, we must not compare ourselves as teachers to not having us, but we must compare innovations to other innovations.* He concludes that *... compared to not having computers, they are influential, but compared to other influences, they are not very influential.* He also calculated the typical effect of schooling over 357 meta-analyses and found the effect size to be 0,40. The following table provides a summary of innovations below this 0,40 typical effect.

	No. of Effects	Effect-Size
<i>OVERALL EFFECTS</i>	165 258	0,40
Peers	122	0,38
Advance organizers	387	0,37
Simulation & games	111	0,34
Computer-assisted instruction	566	0,31
Instructional media	4421	0,30
Testing	1817	0,30
Aims & policy of the school	542	0,24
Affective attributes of students	355	0,24
Calculators	231	0,24
Physical attributes of students	905	0,21
Learning hierarchies	24	0,19
Ability grouping	3385	0,18
Programmed instruction	220	0,18
Audio-visual aids	6060	0,16
Individualisation	630	0,14
Finances/money	658	0,12
Behavioural objectives	111	0,12
Team teaching	41	0,06
Physical attributes of the school	1850	-0,05
Mass media	274	-0,12
Retention	861	-0,15

**Table 1: Examples of innovations below the typical effect (Hattie 1999)**

It is also insightful to take a look at the influences that score above the typical effect as provided by the following table.

	No. of Effects	Effect-Size
<i>OVERALL EFFECTS</i>	165 258	0,40
Reinforcement	139	1,13
Students' prior cognitive ability	896	1,04
Instructional quality	22	1,00
Instructional quantity	80	0,84
Direct instruction	253	0,82
Acceleration	162	0,72
Home factors	728	0,67
Remediation/feedback	146	0,65
Students disposition to learn	93	0,61
Class environment	921	0,56
Challenge of goals	2703	0,52
Bilingual programs	285	0,51
Peer tutoring	125	0,50
Mastery learning	104	0,50
Teacher in-service education	3912	0,49
Parent involvement	339	0,46
Homework	110	0,43
Questioning	134	0,41

**Table 2: Examples of innovations above the typical effect (Hattie 1999)**

The literature that has been reported above gives an emerging picture of computer interventions probably not contributing significantly to learning. Draper (1996) takes the

argument a step further and questions the practicality of investigating the effect of computer interventions on learning. He remarks that:

*Many studies begin with questions like "Do the students learn more with the new software?" But you must ask yourself whether you are sure the question given you is the right question.*

Just like Joy (see p. 15), Draper (1996) also questions the validity of studies that assess whether students have an improved understanding of the learning material:

*... the learning outcomes in fact depend on many other factors besides the intervention being tested, many of which cannot be effectively controlled, e.g. the enthusiasm the teachers and children feel about the methods being compared. Furthermore we are too ignorant of what these factors are to have any confidence that they are controlled in any experiment. Such experiments can be taken as establishing that it is now reasonable to take the new intervention seriously having performed well in one real test, but can seldom be taken as proof that it is inherently better or even necessarily effective by itself.*

Ehrmann (1995: 21) criticizes questions about the efficacy of technology-based approaches from another perspective. He argues that one cannot compare the effect of the intervention to the norm, as there is no norm. Empirical research trying to measure the effect compared to the norm would, according to Ehrmann, be based on an incorrect assumption.

Reeves (1995) classified articles in the journal *Educational Technology Research and Development* (ETR&D) and the *Journal of Computer-based Instruction* (JCBI) over the periods 1989-94 for ETR&D and 1988-93 for JCBI. He found that *Thirty-nine articles (38% of the total 104) in ETR&D and fifty-six articles (43% of the total 129) in JCBI fall into the "empirical-quantitative" cell of the matrix.* To understand this finding it is necessary to note the significance of the empirical-quantitative cell. Empirical refers to the goal or intent of the article or study. Reeves (*ibid.*) defines empirical as *... research focused on how education works by testing conclusions related to theories of communication, learning, performance and technology.* Quantitative refers to the methodologies employed in the

research studies. Quantitative is then defined as *experimental, quasi-experimental, correlational and other methods that primarily involve the collection of quantitative data and its analysis using inferential statistics.*

Reeves (1995) continues his analysis of these articles by measuring them against his nine characteristics of pseudo-science. He found that 72% of the studies in the "empirical-quantitative" category reported in ETR&D could be identified as examples of pseudo-science in that they possessed two or more of the nine characteristics. In JCBI 61% of "empirical-quantitative" studies published during this period suffered two or more signs of pseudo-science. He concludes that ... *this analysis is evidence of a research malaise of epidemic proportions.*

Cronbach (cited in Reeves 1995) warned that *empirical research may be doomed to failure because we simply cannot pile up generalizations fast enough to adapt our instructional treatments to the myriad of variables inherent in any given instance of instruction.*

Some authors have identified reasons why computer interventions could fail to enhance learning. Reeves (1998: 39) mentions that longitudinal studies have shown that pedagogical innovations and positive learning results do eventually emerge from the use of technology, but they take longer than anticipated. One such a study was undertaken by the Apple Classroom of Tomorrow (ACOT) Project. Harrington-Leuker (1997: 8) mentions that school systems need to make a substantial commitment to assist teachers in the use of ICT. Harrington-Leuker warns that the process could take time and supports this warning by listing the five stages identified by the ACOT project through which teachers move when using computers. These stages are the entry stage, the adoption stage, the adaptation stage, the appropriation stage and the invention stage. It is reported that each stage called for a unique type of support. Harrington-Leuker concludes that one needs more than technology: a pedagogical plan is imperative.

Education World (1999: 3) states that successful programs have three factors in common:

- Software supplemented the teaching;
- Teachers received ample training;
- Students had access to up-dated software and well-functioning computers.

Kleiman (2000: 2) mentions that many computers in schools are not often used effectively to enhance learning. He mentions the following reasons for this:

- Due to a lack of training, teachers do not integrate technology into the normal classroom instruction. Computers are then used to provide drills or occasionally for special activities. Kleiman claims that this does not justify the size of the investment;
- Teachers don't have software relevant to the curriculum that is well designed for classroom use;
- Insufficient technical support means that teachers do not use technology for important purposes in the classroom;
- Availability of computers is inconsistent with teachers' approach to teaching. With computers in the classrooms, teachers have to arrange activities so that some learners are working on computers, while others are engaged in other tasks. Where schools have computer labs, teachers have to schedule activities well in advance to move the whole class to the lab. Computer activities then become special events and are not integrated into normal curriculum delivery;
- Publishers develop materials only as supplements to other class work as developers cannot assume that the expertise exists in the schools to integrate the use of technology into the classroom.

Kleiman (*ibid.*: 5) also warns that the impact of technology must be tailored to the educational needs. He says ... *we don't want the cart filled with computer hardware to lead the educational horse*. He also confirms the view that it takes years for teachers to develop the skills that are needed to integrate technology into teaching.

From the insights provided by Kleiman and Harrington-Leuker given above, it seems that technical and/or practical effects could be responsible for hampering the positive influences of computer interventions. This suspicion is strengthened by the work of Carter (1999), Vasu (2002) and Ehrmann (2000).

Carter (1999: 5) concludes that his own study together with studies by Holzman-Benshalom (1997 cited in Carter 199: 4) and Peterson & Orde (1995 cited in Carter 1999: 5) emphasized the finding that ... *initial use of computer-based instruction made students insecure with the instructional method and the technology*. Carter (*ibid.*: 5) also points out that a study by Caftori (1994) showed that students tend to become side-tracked by

interactive media and explored features that were not relevant to the learning objectives of projects.

Vasu (2002) found that, as predicted by the ACOT study, it took a considerable time for computer interventions to pay off. Vasu (*ibid.*: 2) points out that it takes five years for large-scale interventions to reach initial goals and that teaching practices only changed after about seven to ten years.

Ehrmann (2000) argues that it is important to identify and lower the barriers that hinder effective implementation. He warns that computers and computer infrastructure are expensive and that their value diminishes quickly. One could conclude from Ehrmann's argument that it is important to take cognisance of the factors that could negatively affect the use of computer interventions before implementing those interventions. Ehrmann (1995: 24) also criticizes researchers like Kulik for focusing exclusively on the educational value of software and not taking cognisance of factors influencing viability. He also warns (1995: 27) that single pieces of software used for only a few hours cannot have as positive an influence as software that is used repeatedly.

Reeves (1995) believes that we should *call a moratorium on our efforts to find out how instructional technology can affect learning through empirical research. Instead, we should turn our attention to making education work better.* He argues that this could be done by engaging in ... *developmental research situated in schools with real problems.* Developmental research is defined as ... *research focused on the invention and improvement of creative approaches to enhancing human communication, learning and performance through the use of technology and theory.* Reeves (1995) pleads for socially responsible research and quotes a past president of the American Educational Research Association (AERA):

*... the value of basic research in education is severely limited, and here is the reason. The process of education is not a natural phenomenon of the kind that has sometimes rewarded scientific investigation. It is not one of the givens in our universe. It is man-made, designed to serve our needs. It is not governed by any natural laws. It is not in need of research to find out how it works. It is in need of creative invention to make it work better.*



One needs to take note that Bloomfield (cited in Khanya – Education through technology 2002: 51), head of the needs analysis project for WCED Khanya Technology in Education initiative, stated that ... *in 41% of the 1556 schools in the Western Cape less than 50% of the educators are PC literate. There are 122 schools without a single educator that is PC literate ... The immediate focus is to address crisis learning areas such as Higher Grade Maths and Science.*

If one considers the warnings in literature as reported in this section and brings the South African situation of low computer literacy and under-qualified teachers into the equation, it may become clearer why I was wary of developing and testing a computer intervention that would be too taxing on teachers' expertise. One would then run the risk that the factors mentioned by the ACOT study and by Kleiman (see p. 20) could be the cause of the intervention not being used often enough to become a viable solution to helping these teachers. This is why I have assumed that it may be wise rather to take a step back to determine if it is not possible to use computers to help under-qualified teachers, while not placing an extra burden on them.

This section has shown that the literature has also issued a warning regarding pseudo-scientific studies (see p. 19) and studies that do not present viable solutions (see p22). In this regard I have noticed that some studies make themselves guilty of employing recursive arguments when drawing conclusions and also investigate interventions that do not offer viable solutions to the greater educational community. A case in point is a study by Kearney completed in 2002. The study focused on employing a POE (Predict, Observe, Explain) strategy to elicit and promote discussion about learner's preconceptions in Physics. The reason why this is an example of recursive reasoning in drawing conclusions is that the study makes use of a constructivist-based intervention to deduce something about one of the assumptions of constructivism, i.e. the existence of preconceptions. The POE strategies were designed to elicit preconceptions that were identified beforehand in the literature. Seeing that the intervention was specifically designed with the said preconceptions in mind, one has no way of knowing that the strategy employed did not invoke the identified preconceptions. To deduce that the strategy has made it possible to elicit the preconceptions would therefore be unsubstantiated and possibly invalid. It is interesting to note that only those preconceptions already identified in the literature could be elicited from this intervention, which means that the study did not really give us any new information about



preconceptions. Unfortunately the study also employs a very costly intervention that requires the use of a computer network in the science classroom. This makes this type of intervention unattainable to most schools. It is therefore in stark contrast to Reeves's plea for socially responsible research and Ehrmann's warning against not bearing viability in mind.

One may be tempted to structure a theoretical framework incorporating the numerous experimental and descriptive comparative research studies that have been done to try and find significant learning gains achieved by incorporating some or other media intervention. It is, however, clear that a number of researchers question the validity of these studies as well as the conclusions drawn from them. The words of Cline (2003: 1) ring true here ... *there are usually multiple frameworks ... the more viable often being obscured by the dominance of a worn-out paradigm that blinds the observer to alternative views of the world.* In this study I have tried to steer clear of adopting a theoretical framework that would lead to research questions that try and search for learning gains by incorporating media interventions in the classroom. I rather want to determine if the intervention offers a viable solution to helping under-qualified teachers. The viability can be measured by focusing on aspects such as ease of development, ease of use, contribution to the structure of the lesson and acceptance of the intervention by teachers and learners. I support the views echoed in the literature that many studies often draw invalid conclusions owing to the influences of numerous uncontrolled variables. I also support Reeves's plea for socially responsible research and agree with Ehrmann's criticism of studies that do not focus on factors that influence viability.

This brings the discussion to the second point that was raised on p. 13 regarding endeavours of the Western Cape Education department to install computer networks into schools to attempt the technological delivery of the curriculum. These endeavours could now be measured against the warnings reported so far in this section.

### **1.2.3.2 Endeavours of the Western Cape Education department to install computer networks into schools**

Gaum (2002: 21) lists three programmes that the Western Cape Education Department (WCED) have implemented to, as he put it ... (realise) *the full potential of "eLearning" in the Western Cape.*

These programmes are firstly the Telecommunications Project that aims to connect every school to the Internet by the end of 2002. Secondly, the Khanya Technology in Education Project aims to develop innovative ways of using ICT to deliver the curriculum. Thirdly, the Dassie (Distributed Advanced Strategic Systems for Industrial eLearning) Project focuses on vocational and technical training in the Further Education and Training band.

Kobus van Wyk, manager of the Khanya Project, (Khanya: 32) insists that schools have to contribute to the funding of ICT labs. He mentions costs of security, new flooring, furniture, upgrading of electricity supply and increased telephone bills. Van Wyk acknowledges that facilitators are needed to assist educators who are not trained in delivering the curriculum via technology.

Van Wyk (Khanya: 32) also lists four sub-projects to the Khanya project. One of these is a Learning Management System that aims to make curriculum content available to the schools. He mentions that curriculum content has to be appropriate and cost effective, and that the development of content has to be initiated. He mentions Science as one of the crisis areas that need to be focused on in curriculum delivery.

Brian Schreuder (Khanya: 51), Director of Education Planning for the WCED, mentions that Khanya is starting by setting up labs, but that the goal is to link up every desk in every classroom with a terminal to a network. He also mentions Science as one of the crisis learning areas that is an immediate focus of the project.

Schreuder adds that the WCED wants to develop an eCurriculum that will make many teaching and learning resources available to teachers for download off the Internet. As far as the development of software goes, he says (Khanya: 53):

*Through Khanya we aim to stimulate a curriculum software industry ... We need the development of local material that is tailor made for South Africa with relevant levels for relevant grades.*

Schreuder admits that training and supporting teachers are challenges in implementing ICT.

To summarise, it would seem that the WCED wants to use ICT to deliver the curriculum. It would seem that a motivation behind this implementation programme is to try and level the playing fields. Daniels (Khanya: 54) mentions that ... *using ICT effectively could mean overcoming limited expertise in the disadvantaged schools*. Another motivation is to inspire the teachers and to re-evaluate their methods. In this regard Daniels says:

*It is obviously easier to keep everything relevant and current as they have access to constantly updated information ... we need technology to develop inspired and inspiring teachers.*

In their effort to deliver the curriculum, the Khanya Project plans to put computer labs into schools. Van Wyk (Khanya: 32) estimates that a lab with 25 workstations and educational software costs around R500 000. Ultimately these labs will be extended to computers in each classroom.

Kleiman (2000: 4) mentions the following example as a goal in education that makes it possible to design the technology around the goal (in other words, it does not lead to a situation where the “cart filled with computer hardware leads the educational horse”):

*Enable teachers to strengthen their own approaches. For example, a Science teacher who primarily lectures may use a computer and a large display to provide visual support for the lectures, while another teacher who favours a more enquiry based approach may add simulations and experiments with computer based measuring devices and analysis software.*

Kleiman's example sounds very much like the descriptions presented on p. 1 of this chapter for the CAIR and TRAC interventions. Although I respect the attempts of the Khanya project to use ICT to deliver the curriculum, the method of implementation seems to be exactly what some researchers are warning us against. Many of our Science teachers are struggling with the curriculum. Putting computer labs into schools poses a new challenge to them and may not necessarily be a solution. These teachers still have to go through the different stages identified in the ACOT Project. They now need to become familiar with the technology, and then they need to plan how to use it. Classroom activities need to be scheduled in computer labs in addition to delivering a curriculum that they are

unsure of. It seems that the introduction of ICT in this way will either require teachers to become more specialised than they are now, or the support will have to be very good and readily available at very short notice. Khanya has acknowledged the need for support, but judging from international studies cited in the previous section, the process could be much more complicated than Khanya may have realised. In the development and testing of the CAIR the following issues will need attention.

Firstly the main intention of the CAIR must not be seen as an attempt to introduce technology into the classroom. Rather, technology must be seen as an opportunity to assist teachers who are struggling. The CAIR must therefore be designed around the curriculum to be used by teachers in their normal classroom activities as a resource and an aid. This will help teachers to get through the initial entry stage and adoption stage that the ACOT study has identified (see p. 20). The implementation of the CAIR must therefore be based on a pedagogical goal rather than a technological one. This is probably the first step that is needed for teachers who need to learn how to crawl first with technology before they can walk. The CAIR should try to assist teachers in structuring their lessons. In this way they will become more comfortable with the subject matter and knowledge that may now be lacking and then move on to the other stages that ACOT has identified.

The second aspect that the implementation of the CAIR needs to address is the one of cost. This would involve cost of development, as well as cost of implementation.

Thirdly, Schreuder (see p. 25) acknowledges the need for locally designed software. The CAIR should therefore be designed for local use and software should be developed on a format that will assist the WCED in their quest to develop an eCurriculum.

Fourthly, Reeves (1998: 29) reminds us that the design of media and technology for education is as much a craft as it is a science, as there are no infallible instructional design formulas. Najjar (1996: 18) makes some recommendations on which types of presentation media support which type of information best. This study will need to report on an evaluation process to address design aspects relating to the CAIR. It will also have to focus on issues such as training and technical support (two of the important aspects mentioned by Kleiman – see p. 21).

Fifthly, Daniels (see p. 26) has stated that technology should inspire the teachers and learners. It would be important to report on how the CAIR and TRAC interventions are received by both teachers and learners. The low computer literacy rate (see pp. 22-23) of teachers needs some consideration in the design to ensure that the program could be used by teachers with limited computer experience.

I would urge educational authorities to rethink their implementation of ICT into schools and to make sure that strategies are based on sound pedagogical goals rather than on the need to put technology into schools. Technology is a tool and teachers are the facilitators who need to use those tools. The tools therefore need to serve the needs of those teachers. The implementation of these tools has to happen at a pace that is comfortable for teachers, so that the effort that is put into using the tool justifies the educational dividends that can be collected from that use.

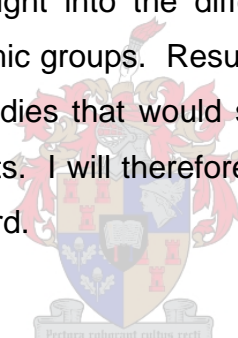
#### **1.2.4 The effect of gender, language and socio-economic standing on attitudes towards computers**

A number of authors have attempted to address the effect that factors such as socio-economic standing or gender could have on peoples' attitudes towards computers. Bontempi (2003: 4) claims that students from lower socio-economic standing may particularly benefit from computer-aided instruction. Deeds *et al.* (2002: 1) refer to the digital divide as a result of social issues and refer to the technological gender gap as indicating that males and females have different attitudes, behaviours and skills when it comes to technology. They report a more positive attitude in males than females and claim that males are more likely to follow a technological career than females.

The New Zealand's National Education Monitoring Project held a technology survey in 1996 reporting that boys and girls performed similarly in tasks, but that students from a low socio-economic standing had lower levels of performance. Christensen and Knezek (2002: 5) report that a more positive attitude in males towards computers only starts becoming apparent after Grade 6. Lal (2002: 6) summarises the findings of a number of research-based studies relating to the impact of computer-based technologies on different genders. Lal concludes (2002: 6) ... *that there is a range of differences in how boys and girls access, use and interact with computer-based technologies*. McCullough (2000: 30) reports that males tend to use computers more outside of school. She also mentions that research is split between those who label females as more computer-phobic than males

and those who find no differences. She cites a number of researchers (Guttschow 1999; Busch 1996; and Comber, Colley, Hargreaves & Dorn 1997) who found that females tend to enjoy computers less than males. Although she also reports that it has been shown that males outperform females on tasks involving computers, she sites Berge (1990) as having found no difference between the ways that boys and girls learn Science process skills with the computer.

Unfortunately these studies don't seem to offer any insight into what could be expected from the responses from different groups in this study as different studies seem to reach different conclusions. These studies therefore leave one with the impression that some research needs to be done to clarify some of the issues. As it is not the focus of this study to offer a comprehensive report on the differences in responses between different gender, language and socio-economic groups, these issues will not be explored any further in this section. The study does, however, present an opportunity to use demographic data from the respondents to gain some insight into the differences in responses from different gender, language and socio-economic groups. Results from such analyses may be useful in making recommendations for studies that would specifically want to focus on gender, language and socio-economic effects. I will therefore use the opportunity to try and make some recommendations in this regard.



### **1.3 Stating the research questions**

Where the previous section reported the issues that inspired me to embark on the course of action described in this study, this section wants to formalise the questions that are to be investigated. Although the need to address these issues has been addressed elsewhere in this chapter, it is repeated here for the sake of focusing the reader's attentions on the objectives of this study.

#### **Question one:**

What are the relevant principles that need to be considered in designing an instructional resource?

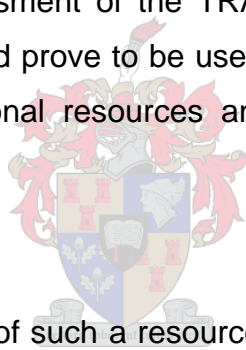
#### **Question two:**

What are the technical aspects that need to be considered to develop software that can be used as an instructional resource in classrooms?

**Question three:**

How are the instructional resources received by teachers and learners?

By using the term instructional resources the question is referring to both the CAIR and TRAC applications. At this point it is necessary to make a few remarks about the assessment of the TRAC system in this study. While the focus here is on the instructional resource, the TRAC system also has the potential to be used as an instructional resource in the classroom and not just as a practical investigation for reinforcement after theory has been taught. While some studies are being conducted about the effect that the TRAC system has on learning, I was more concerned with how the TRAC system was received by learners and teachers. A particular point of interest would be to try and establish if teachers integrated the TRAC system into the learning process or whether it was used only after the theory had already been taught. I subsequently decided to use the opportunity to include some assessment of the TRAC system to try and shed light on these issues. This information could prove to be useful in designing future resources that may possibly incorporate instructional resources and practical resources in the same package.

**Question four:**

Is there any indication that the use of such a resource could assist teachers in structuring lessons?

**1.4 Aims**

1. To research guidelines for and to develop software that would function as an instructional resource. This section of the study is specifically aimed at addressing questions one and two mentioned above. (see p. 29). Results of the research are reported in Chapters 3 and 4. The area of study is Grades 11 and 12 Newtonian mechanics;
2. To train teachers from project schools in the use of the software as a resource for instruction. The mechanics of the training process are reported in Chapter 4;
3. To establish criteria for the evaluation of the effectiveness of the software and of the instructional method. The chosen criteria are reported in Chapter 2;
4. To develop instruments to apply the criteria for evaluation. The development of instruments is reported in Chapter 5;



5. To use the developed instruments in assessing the instructional software, as well as some aspects of the TRAC system in the project schools. This section of the study is aimed at addressing questions three and four (see p. 30). The results of this assessment are reported in Chapter 5;
6. To adapt and improve the software and instructional method by taking into account my own observations as well as comments from teachers and students. These aspects are discussed in Chapter 6;
7. To report the findings of the study.

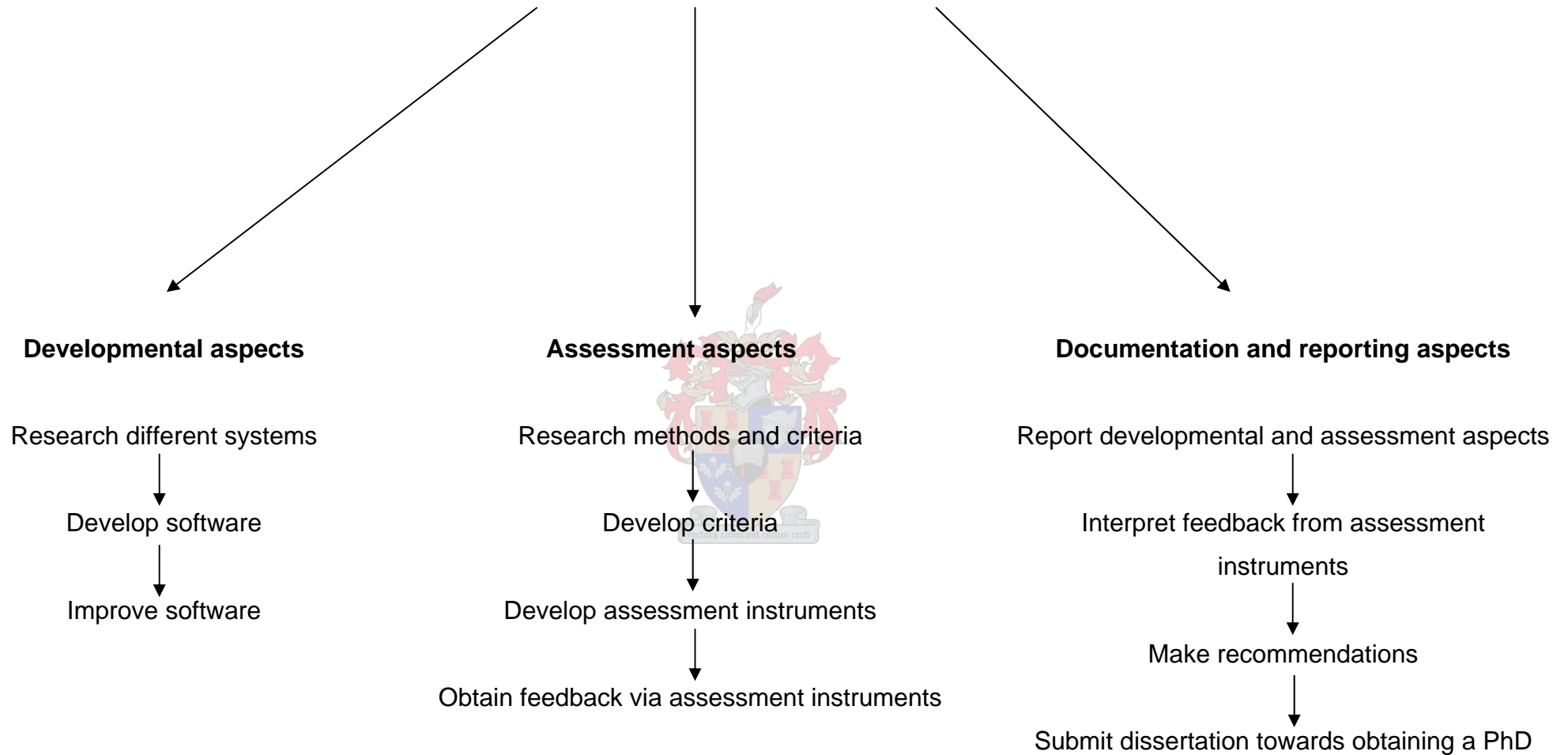
After completion, I hope that the outcome of the study will be presented to the broader business community with two aims in mind:

1. To obtain the interest and commitment from private companies to sponsor schools by supplying computers connected to televisions;
2. To get Science teachers all over South Africa interested in developing software to be used in classrooms and disseminated via the Internet. The ideal is that schools will have access to these resources via the Internet.





## Aspects of the evaluation of a Computer- Aided Instructional Resource in teaching Physical Science



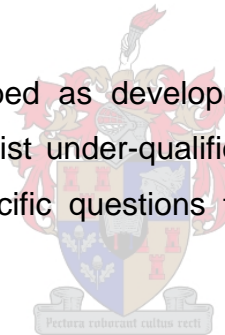
**Diagram 1**

## 1.5 Overview of the dissertation

Chapter 1 has presented the theoretical framework by presenting an integrated discussion of both experience theory and literature theory. In this discussion I have tried to meet the validation function of this section by following Cline's (2003: 5) two suggestions. Cline suggests that one needs to demonstrate the relevance of the framework to the study and show that it has more advantages / fewer disadvantages than some other framework.

Firstly, this chapter has shown that the framework that is presented is relevant to this study by relating each section to either the development or testing of the CAIR or TRAC. Secondly, it has shown that the framework is more advantageous than one that would support the investigation of the effect of computer interventions on learning. The discussion has done so by quoting relevant literature criticising numerous studies that have attempted such investigations and has also presented alternative questions that need to be answered.

The study can broadly be described as developmental research focused on socially responsible, viable solutions to assist under-qualified Science teachers in delivering the curriculum. This has led to specific questions that were formalised in the previous section (see p. 29).



Chapter 2 shows how the questions posed and the theoretical framework influence the choice of investigative methods employed in this study. It will then continue to define criteria for evaluation.

Chapters 3 and 4 focus on the development of the CAIR by reporting principles and technical aspects of software development. Chapter 4 also reports on the training process as this forms an integral step in the developmental strategy that will be reported in Chapter 2. This relates to issues identified in the discussion in Chapter 1 as well as research questions 1 and 2.

Evaluation of the CAIR and TRAC is reported in Chapter 5 and the discussion of these results is presented in Chapter 6 together with recommendations for further research.

## Chapter 2

# DEFINING THE METHODOLOGY AND CRITERIA FOR EVALUATION

## 2.1 Defining Methodology

### 2.1.1 Introduction

In Chapter 1 the theoretical framework made it possible to focus the definition of research questions. For the sake of coherence, these questions should guide the study towards identifying the techniques that will be employed to produce data that are needed for both the development and testing of the CAIR.

The theoretical framework presented in Chapter 1 has established that the data produced from the empirical investigation will not focus on the learning gains of the learners, but need to provide an insight into issues like ease of use of the intervention, teacher and learner attitudes towards the use of the CAIR and TRAC, empowerment of teachers to become more effective, technical difficulties and edutainment value. (By edutainment is meant learning that educates and entertains.)

### 2.1.2 Selecting an underlying philosophy

Myers (1997) as well as Ratcliff (2002) mention three underlying philosophical perspectives that underpin all research. These are positivist research, interpretive research and critical research.

Trochim (2000b) categorises research under two broad headings, these are positivism and post-positivism. He broadly describes the difference between the two as follows:

*... Where the positivist believed that the goal of science was to uncover the truth, the post-positivist critical realist believes that the goal of science is to hold steadfastly to the goal of getting it right about reality, even though we can never achieve that goal! ... Because all measurement is fallible, the*

*post-positivist emphasizes the importance of multiple measures and observations, each of which may possess different types of error, and the need to use **triangulation** across these multiple errorful sources to try to get a better bead on what's happening in reality. The post-positivist also believes that all observations are theory-laden and that scientists (and everyone else, for that matter) are inherently biased by their cultural experiences, world views, and so on. This is not cause to give up in despair, however. Just because I have my world view based on my experiences and you have yours doesn't mean that we can't hope to translate from each other's experiences or understand each other.*

Trochim (2000b) warns, however, that one can easily ... *get lost in the maze of philosophical assumptions that contemporary philosophers of science argue about.* He argues that these types of philosophical debates will continue for many years to come and that one needs to become pragmatic about these matters. He concludes that:

*... Those of us who are practicing scientists should check in on this debate from time to time (perhaps every hundred years or so would be about right). We should think about the assumptions we make about the world when we conduct research. But in the meantime, we can't wait for the philosophers to settle the matter. After all, we do have our own work to do!*

Unfortunately this advice does not help much to identify a philosophy that is appropriate to this study. Le Grange (2001: 138) offers a clearer view on the matter. He distinguishes between positivist, interpretive and critical approaches. He points out that critical research challenges the objectivist ideas that knowledge is ... *impersonal and objective* and that ... *reality exists independently of our knowledge of it.* According to Le Grange (2001: 139), critical and interpretive research both share the view that we socially construct our knowledge of reality. He emphasises, though, that the critical approach differs from an interpretive approach in that the former does not only try to understand social reality, but it tries to transform the world to become more just and equitable. Le Grange summarises it as follows (*Ibid.* 2001: 139):

*... In essence what distinguishes critical research from more conventional ones is that it is openly ideological (it is not value neutral), socially critical,*

*overtly political, and emancipatory in orientation (aims to liberate the participants involved in the research).*

Le Grange has managed to pin down the differences between the different approaches. One may still want to ask how the philosophical approach relates to the research.

A literature research into research methodology highlights two different approaches that are often referred to as qualitative and quantitative methods. These could be quite confusing to a Science educator. In Science education one could use the example of the analysis of an unknown solution to describe the difference between a qualitative and quantitative analysis. Qualitative refers to an analysis that aims to identify what the solution consists of and quantitative refers to an attempt to determine the quantities (e.g. concentration) of substances in the solution. However, in research methodology the distinction seems to describe the approach and methods used in the research design and the type of data produced rather than the aim of the research. As this study was concerned with testing a computer-aided resource, I decided to search the available literature to obtain a clearer view of the difference between qualitative and quantitative approaches, where they are specifically described for research design regarding information and communication technology.

Myers (1997) mentions that quantitative research was developed to study natural phenomena in the natural sciences, whereas qualitative methods were developed to enable researchers in the social sciences to study social and cultural phenomena. This becomes confusing, as it sounds very similar to the reasons given for the difference between positivist and post-positivist approaches (see pp. 34-35). Myers continues to point out that because people can talk, qualitative methods make it possible to understand a phenomenon from the point of view of its participants and their particular social and institutional context. This understanding is believed to be largely lost when textual data are quantified. Myers (1997) lists four methods that are particularly important in qualitative research in information systems. They are:

1. Action research
2. Case study research
3. Ethnography
4. Grounded research.

The following debate also highlights the confusion between actual research methods and underlying philosophical assumptions:

Kock (1997) addresses the issue of action research as opposed to positivism. He indicates that some researchers see action research as opposed to positivism and that some even feel the need to apologise for the use of methods that are believed to belong to the positivist tradition. Kock concludes that it is a myth that action research opposes positivism as it can be supported by positivist assumptions. Myers agrees that positivism can underpin action research just like interpretive and critical approaches can be incorporated. Myers classifies action research as a qualitative method, but Kock argues that this is a myth as he has experienced that action research can benefit from simple statistical analysis. He mentions techniques like content frequency analysis in texts and correctional analysis.

This confusion between methods and philosophical approach could be eliminated by following the advice of Le Grange (2000: 194). He proposes that we abandon the use of the term 'qualitative' when describing research. He prefers the term post-positivist to describe contemporary educational research and argues that the use of 'qualitative' and 'quantitative' should rather be used to describe the use of data. This is consistent with Hoepfl's (1997: 1) argument that quantitative data are produced by statistical procedures, whereas qualitative data are more descriptive in their nature. Authors like Russek and Weinberg (1993) (cited in Hoepfl 1997: 2) and Ratcliff (2002) advocate the use of both qualitative and quantitative data in research studies. This means that the two terms need not be mutually exclusive in the same study.

In this study the terms qualitative and quantitative will be used to distinguish between different types of data. The underlying philosophy is an interpretive approach whereby data will be produced by my interpretations of responses and events.

### **2.1.3 Developmental Methodology**

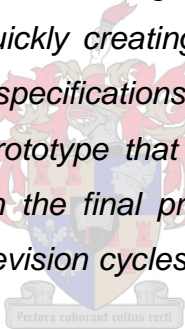
The previous section identified an interpretive approach as underpinning the production of data, but did not spell out the specific structure of the research design or the techniques employed to produce data. This section will consider principles of rapid prototyping, instructional design, evaluation research and open content development to synthesize the basic structure of the research design. The next section will show how the techniques

employed are integrated into the research design and how these techniques relate to the underpinning interpretive approach.

In keeping with Reeves's plea for developmental research (see p. 22), the basic research design has to support the quest of developing and testing the CAIR. The research design should therefore support both the developmental and testing processes.

Gustafsen and Branch (1997: 77) identify the following core elements to instructional design: analyse, design, develop, evaluate, implement. They also identify two types of design for instructional courses. These are so called traditional instructional design (ID) and rapid prototyping (RP). Gustafsen and Branch (1997: 85) list the differences between the two processes in a table format, but briefly describe the contrasts as follows:

*In contrast to traditional ID, that relies on extensive front-end analysis of needs and detailed specification of goals and requirements, rapid prototyping usually involves quickly creating a general sense of what the goal is and only limited design specifications. This is followed by rapid (and low cost) development of a prototype that contains at least some of the operational features desired in the final product. Then, through a rapid series of iterative tryouts and revision cycles, the product is shaped until an acceptable version is created.*



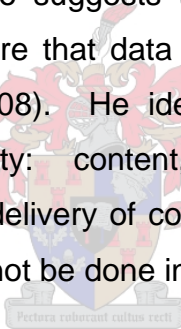
Pham (1998: 108) also describes a process by which feedback can be obtained at various developmental stages to assist with design improvements and development.

The development and testing goals in this study can be integrated into a single design, as the iterative try-outs would need to incorporate evaluation of the product to measure the success of each try-out. Trochim (2000a) identifies two types of evaluation, namely formative and summative evaluation. He describes formative evaluation as an attempt to ... *strengthen or improve the object being evaluated -- they help form it by examining the delivery of the program or technology, the quality of its implementation, and the assessment of the organizational context, personnel, procedures, inputs, and so on.* Trochim identifies five types of formative evaluation:



- needs assessment determines who needs the program, how great the need is, and what might work to meet the need;
- evaluability assessment determines whether an evaluation is feasible and how stakeholders can help shape its usefulness;
- structured conceptualization helps stakeholders define the program or technology, the target population, and the possible outcomes;
- implementation evaluation monitors the fidelity of the programme or technology delivery;
- process evaluation investigates the process of delivering the programme or technology, including alternative delivery procedures.

The Ministry of Economic Development in New Zealand has identified four types of evaluation methods for industry development initiatives. One of the four is again Implementation evaluation and it is described as evaluating the delivery and administration of an initiative. Their document also suggests that evaluation needs to be designed together with implementation to ensure that data will be available when required. This view is shared by Pham (1998: 108). He identifies three elements of educational multimedia design that affects quality: content, representations and organisation of content and technical tools used for delivery of content. He warns that the development and evaluation of these elements cannot be done in isolation from each other.



The World Health Organization (2003) has also provided a document on implementation evaluation. The document suggests that assessing the intervention's impact under this model means looking at three issues:

- The extent to which the intervention has reached the target population;
- Activities undertaken and services delivered;
- The resources needed to deliver the intervention.

Each of these issues is discussed in more detail in the document. From this discussion, these issues can also be interpreted in terms of the evaluation of the CAIR to mean:

- How the CAIR was received by the intended population;
- Training and technical support;
- Feasibility of intervention with respect to the cost of hardware requirements.



Pham (1998: 119) identifies four main approaches for evaluation. These are called objective-based, decision-based, value-based and naturalistic evaluation. The first three deal with the evaluation of the product and its outcomes and ignores the effects on users explicitly. The naturalistic approach does, however, focus on user's views, interests and experiences. In the naturalistic approach data are produced by the use of observations, interviews and questionnaires.

Laurillard (cited in Draper 1996) outlines a five-step evaluation programme. Although this type of evaluation is more applicable to the type of software that students will use directly in tutoring-type exercises, it becomes interesting to note which types of techniques are suggested within each step of the evaluation programme. Observation, interviews and questionnaires seem to be the most frequently used techniques in the majority of the steps. These methods are of the type that Reeves (1995) would classify as qualitative. The Multimedia Education Group, University of Cape Town (1999) has suggested an adapted version of Laurillard's evaluation programme for the evaluation of their projects. They seem to use Laurillard's model with a variation as suggested by Draper (1996). As the focus in this study is on an instructional resource, an adapted version of the Laurillard model is suggested to evaluate aspects that are unique to the CAIR. In this adapted model the rapid prototyping principles described by Gustafsen and Branch (1997: 77) are also given consideration by building multi-stage evaluation into the process. The stages are as follows:

1. Pre-Program Design Stage: The curriculum is analysed and a learning material structured in a way that would make it suitable for instruction in the classroom;
2. Prototyping Stage: In this case it would be inaccurate to describe the software that was developed for this study as a prototype. This software was actually preceded by PowerPoint presentations that were used in Grades 11 and 12 for two and a half years. During that time it was evaluated informally by using interviews and questionnaires at the end of each year. A total of 134 students received instruction using this software over the two-year period. At the end of the first year the software was adapted to address the shortcomings identified by the students. This stage has therefore been continuously implemented during the period 1998 to 2000. The result of this informal evaluation and the subsequent adaptation of the software are reported in Chapter 5. The prototype version was tested by me in my own classroom before training teachers in pilot schools;

3. Training Stage evaluation: This evaluation involves assessing the effectiveness of the training programme to prepare teachers for the implementation in classrooms. This was done by means of questionnaires, interviews and observation. The evaluation also focused on teachers' attitudes towards using the software;
4. Piloting Stage: The classroom implementation was observed and feedback from teachers and learners obtained via interviews and questionnaires.

This study proposes to develop the CAIR to be delivered via the Internet. The Internet has been identified here as a road to be used on which the CAIR can travel to deliver content to the classroom in a format that teachers can use directly. The reasons for wanting to do so can be related back to my personal experience. I had noticed that, although there are many resources available on the Internet, there are very few that can be used directly in the classroom to serve the South African curriculum. Either content needed to be restructured, or new compilations had to be made from a variety of sources. This is very time-consuming for a teacher.

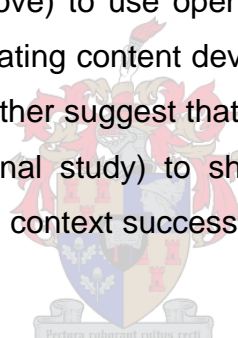
The realisation that the Internet can be used as a pathway to deliver content focuses one's attention on the Internet not as an information highway, but as a communication highway. If teachers are able to gain access to content on the Internet, they can also contribute to the development of content. This leads one to the idea that the Internet can be used for collaborative development of open content. Keats (2003) explains that the idea of open content development originated from the open source software movement. He describes open content development as ... *a license agreement, a philosophy, a way of doing things, as well as the content produced and distributed according to the open content license agreement.*

I have already expressed the desire at the end of Chapter 1 (see p. 31) that a stage will be reached when teachers from all over South Africa can contribute to the developmental process. One may rightfully ask why I chose not to adopt open content development as a developmental methodology for this study. There are a number of reasons for this and they will be given briefly below.

The focus of the study is not content development, but rather the development and testing of the vehicle that carries the content. An investigation into open content development would have meant a rather serious departure from the approved research proposal. The

idea of open content development is still relatively new and has not been tested for content development in secondary Science classrooms in South Africa. There is therefore no indication of the time frame needed to develop content in this way. This may have caused serious problems in trying to complete the study within the given time constraint. The low PC literacy rate as reported in Chapter 1 (see pp. 22-23) could have meant that too few contributions may have been received from teachers to develop the content. This could have led to premature failure of the project. It is further possible that teacher involvement in content development could have caused bias in their minds when required to evaluate the product.

It is important to note that teachers were not limited to the use of the CAIR in their teaching during the Piloting Stage. They were free to add resources and examples of their own and to integrate the CAIR in any way they saw fit within their teaching strategies. Although I support the principles behind open content development, I feel that it would be irresponsible (for reasons given above) to use open content development as a tool in a study that is not specifically investigating content development based on the open content development philosophy. I would rather suggest that open content development be tested thoroughly (probably in a longitudinal study) to show that it can be used to develop Science content in the South African context successfully.



#### **2.1.4 Techniques employed**

Various techniques were employed to serve the developmental goal while keeping the underlying interpretive approach in mind. The different stages described in the previous section served the developmental goal while also serving as a structure to deploy instruments that produced quantitative as well as qualitative data. Stage 4 of the evaluation guide of the National Network of Libraries of Medicine in the USA (p. 49) mentions open-ended interviews, direct observation and open-ended survey questions as ways to produce qualitative data.

The use of open-ended questionnaires in this study produced a set of quantitative as well as a set of qualitative data. Respondents were typically required to communicate their like or dislike of a specific feature and were then asked to motivate their responses. This produced a set of nominal data that related responses as being positive or negative. Together with demographic data this set of nominal data could be statistically analysed to search for differences in responses from different groups of respondents.

The motivations, an opportunity to make any additional remarks, researcher observation as well as interviews produced a set of qualitative data that could be used to identify positive and negative aspects by grouping similar motivations. Hoepfl (1997: 7) describes identifying such categories as the big challenge of qualitative research. Within this framework of producing quantitative and qualitative data, the techniques described below were employed.

- The eight schools were chosen to be representative of different communities as well as different classroom demographics in terms of class sizes, sex representation, race and language preference. It was therefore not a specific case study. Class sizes, for instance, varied from 8 to 36. Socio-economic communities varied from previously disadvantaged to affluent. There was also representation of a technical school as well as a girls-only school. Some classes were English medium, while others were a mixture of English and Afrikaans. This approach to purposeful sampling is an attempt of what Patton (cited in Hoepfl 1997: 5) calls maximum variation sampling. The thinking behind this is that the emergence of common patterns from great variation helps to capture core experiences and shared aspects of an intervention. Although the study tried to be as non-selective as possible, it was still limited by schools that were already part of the TRAC project.
- Questionnaires were designed to obtain responses from the various role players at each stage of the study. These questionnaires were designed around carefully chosen criteria as reported in the next section.
- Researcher observation was used during the Training and Piloting Stages. A rubric was designed to focus researcher attention to the specific aspects that needed to be assessed. Field notes were also made during observation where the rubric did not describe an observed phenomenon.
- Interviews were used to clear up issues that became apparent during analysis of responses to questionnaires and researcher observations. During these interviews audio recordings were made for analysis afterwards. Field notes were also made, as a back-up system during interviews, should technical difficulties arise with audio recordings.
- A spreadsheet was used for recording of responses and for labelling of motivations. This was then used to facilitate content frequency analysis of texts.

- Statistical analyses of quantitative data were performed by Prof. Daan Nel at the centre for Statistical Consultation at the University of Stellenbosch. Chi-square tests, Bonferroni One Way ANOVAs and Bootstrap One Way ANOVAs (where residuals did not show a normal distribution) were employed.

### 2.1.5 Reliability of research

The rigour of a study in traditional empirical research relies on the qualities of reliability, validity and objectivity. According to Sanders (1999), the reliability of research that produces qualitative data depends on consistency in the research process and the replicability of results.

Sanders continues to elaborate on the issue of consistency by mentioning the following factors. Results as well as methodology need to be reproducible. Interviews, observational techniques and specimen records should be available?. In this study these factors can be identified in the techniques mentioned in the previous section.

Sanders differentiates between internal and external validity. He describes internal validity as *...how well the researcher measured the phenomena under consideration*. In this study the depth of measurement is apparent from triangulation across various techniques. Questionnaires, observation and interviews were used during various stages. The principle of triangulation is also strengthened by data representing perspectives from teachers and learners.

External validity is gauged by how successful results are applicable to a larger population. Although this is not always relevant to qualitative research, this study attempted to employ the principles of maximum variation sampling in the selection of the schools involved in the Piloting Stage. External validation is also rooted (according to Sanders) in well-documented research and comprehensive description. This study has attempted to report on every aspect of the development as well as the collection and analysis of data.

## 2.2 Defining criteria

### 2.2.1 Introduction

The instruments that were used in the evaluation process and the results obtained are reported in Chapter 5. This section serves to report the defining of criteria that formed the foundation for the design of evaluation instruments.

An important consideration of this study is that computer technology could be introduced into classrooms where teachers may not have a high level of computer literacy. In doing media research on the use of computers in classrooms, special attention was given to technical difficulties that teachers may experience. The following section reports the findings of the literature research aimed specifically at defining evaluation criteria.

### 2.2.2 Literature Research

This section should ideally be read in conjunction with section 1.2.2 (see p. 9) of Chapter 1. This will give a clearer picture of how I arrived at the specific criteria.

Some of the problems reported by Buirski-Burger & Sewell (1998) with integrating computers into classrooms are:

1. Teachers are inadequately trained to use computers;
2. A lack of time for teachers to learn the necessary skills;
3. Computer technology is seen as peripheral to the curriculum and are therefore not properly integrated into the learning experience;
4. Teachers fear change.

Buirski-Burger & Sewell (1998) also report the positive effect that the use of multimedia technology like hypertext authoring and interactive video had on a Grade 7 class. They found improved attitudes in the learners as well as increased motivation and more enjoyment. They also mention though that the learners found the use of the technology quite complicated and that it required a lot of commitment and time.

Self (1985 cited in Buirski-Burger & Sewell 1998) remarked that computer-based programmes should be evaluated on their contribution to the learning and teaching process. In this context Harvey (1994) warns against ... *tailoring your work to the demands of the medium, rather than the other way around*. We have to be careful that we are not merely wanting to use the technology because it is available. The technology has



to fulfil and/or supplement the educational need. Talbott (1996) also addresses this issue by warning against the glamour of using computers.

Feldman, Coulter & Konold (1999: 133) mention that many teachers take a long time to learn new technologies. They maintain that support is needed in the form of ... *ongoing support, tutorials in teacher guides, online training workshops, and access to telephone and e-mail help lines.*

Bennet (1999) warns that one of the problem areas in using computers in classrooms has been the time-consuming process of matching software to the curriculum. Buirski-Burger & Sewell (1998) address the same problem in a South African context :

*The question of applicability must also be addressed. At the present time material designed specifically for the South African Science syllabus is limited to "Electronic Science Tutor" (Delpierre and Sewell, 1995) and a small number of other offerings. Imported material is generally difficult to obtain, expensive, and limited in scope. Over 20,000 programs aimed at the school market (U.S. Department of Education, 1996) have been produced, yet we have been able to locate very few that appear to fulfil the needs of South African Science students in the further education band.*



I have found the same situation to be true almost two years later. Although there has been some development from profit-seeking ventures within the private sector, no adequate presentation software is known to exist on the whole Science curriculum, except that which I have developed for my own use.

Bennet (1999) also warns that *People who use computers regularly are often ill-equipped for trouble shooting.* As teachers are not technical experts, trouble shooting could easily lead to a waste of valuable time.

The US navy's Implementation Evaluation Guide (Navy Handbook for the Computer Security Certification of Trusted Systems 1993: 1) claims that good software can be identified by the fact that it ... *works, meets requirements, is robust, is easy to understand, easy to integrate and easy to test.*

Cronje (2000) breaks up the evaluation process for interactive multimedia (IMM) into nine stages. He then organises his 24 evaluation criteria into four categories. As the software that needs to be evaluated in this study is not an IMM programme but rather a CAIR, all the criteria are not applicable. The following criteria from Cronje (2000) could be useful:

1. Software should have motivational value in helping to keep learner attention;
2. Colour should enhance the legibility and impact of the screen;
3. There should be a good balance of graphics, animation and text to bring a point across;
4. Graphics should make material more attractive, help visualisation and aid understanding and retention;
5. Animation should motivate through aesthetic appeal and/or humour and minimise static boredom;
6. The user needs a basic set of readily available buttons, icons or menu items for: help; escaping and exiting; moving forward; moving back to a previous screen or other relevant material; pausing.

Mayer and Coleman (2000: 2) make a number of references to Ehrmann (1995, 1998, 1999), who suggests that one should not be testing the effectiveness of informational technology by looking at outcomes. One should rather be asking if the use of technology could help teachers ... *integrate "best practices" into their teaching*. They listed a number of basic questions that need to be answered (see Chapter 1 pp. 10-11).

Pham (1998: 109) suggests that in the evaluation of multimedia, three main perspectives should be considered, namely the product itself, how it is used and the impact of the product. Although the article does not focus on presentation software in particular, it contains some suggestions that are relevant to this study. Pham (1998: 113) identifies three aspects to evaluate when focusing on the content. The first is the appropriateness of knowledge content, the second involves complexity level of the content and the third relates to the capacity of tasks to stimulate learning. He suggests further that programmes should be structured as a mixture of instructivist and constructivist approaches as both contain benefits.

He also addresses the issue of evaluating technical aspects (*ibid.*: 116). Here he suggests that one looks at technical features offered by the system. For the evaluation of the CAIR this could be interpreted to mean evaluation of navigation and control tools.



Pham also mentions that one needs to evaluate the reliability of the technical features under extensive use by different users.

Pham (*ibid.*: 118) also calls for the evaluation of the interface by focusing on issues such as ease of use and degree of user's satisfaction. The impact of the product can be evaluated by looking at how well it can be deployed within the curriculum and how well the product compares with alternative systems or ways of doing things.

### **2.2.3 Final criteria**

In this section the developmental goal and information gathered from the relevant literature as reported under sections 1.2.2 and 2.2.2 were considered to define the final criteria against which the success of the CAIR programme was measured. These criteria were then used, keeping the underpinning interpretive approach to the study in mind, to design the instruments to be used in the evaluation process.

In an attempt to focus on the appropriate criteria that would be relevant to each specific stage in the adapted Laurillard model, the criteria were classified into three categories.

#### **Didactical Considerations:**

1. relevance of software to the curriculum;
2. the effect on learner attitudes and edutainment value (enjoyment of the lesson) in keeping their attention;
3. contribution to teaching process in terms of structuring the lesson;
4. effectiveness as a timesaver for the teacher;
5. integration with TRAC system;
6. effectiveness of the notes;
7. correctness and comprehensiveness of content;
8. the flexibility that the resource allows the teacher;
9. way in which the content is presented and uncovered to the learners.

#### **Visual Considerations:**

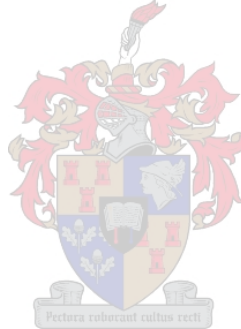
1. effectiveness of animations in visualisation of concepts;
2. contribution of graphics to attractiveness of information;
3. appeal of user interface (visual appeal of software);
4. clarity of presentation.

**Technical Considerations:**

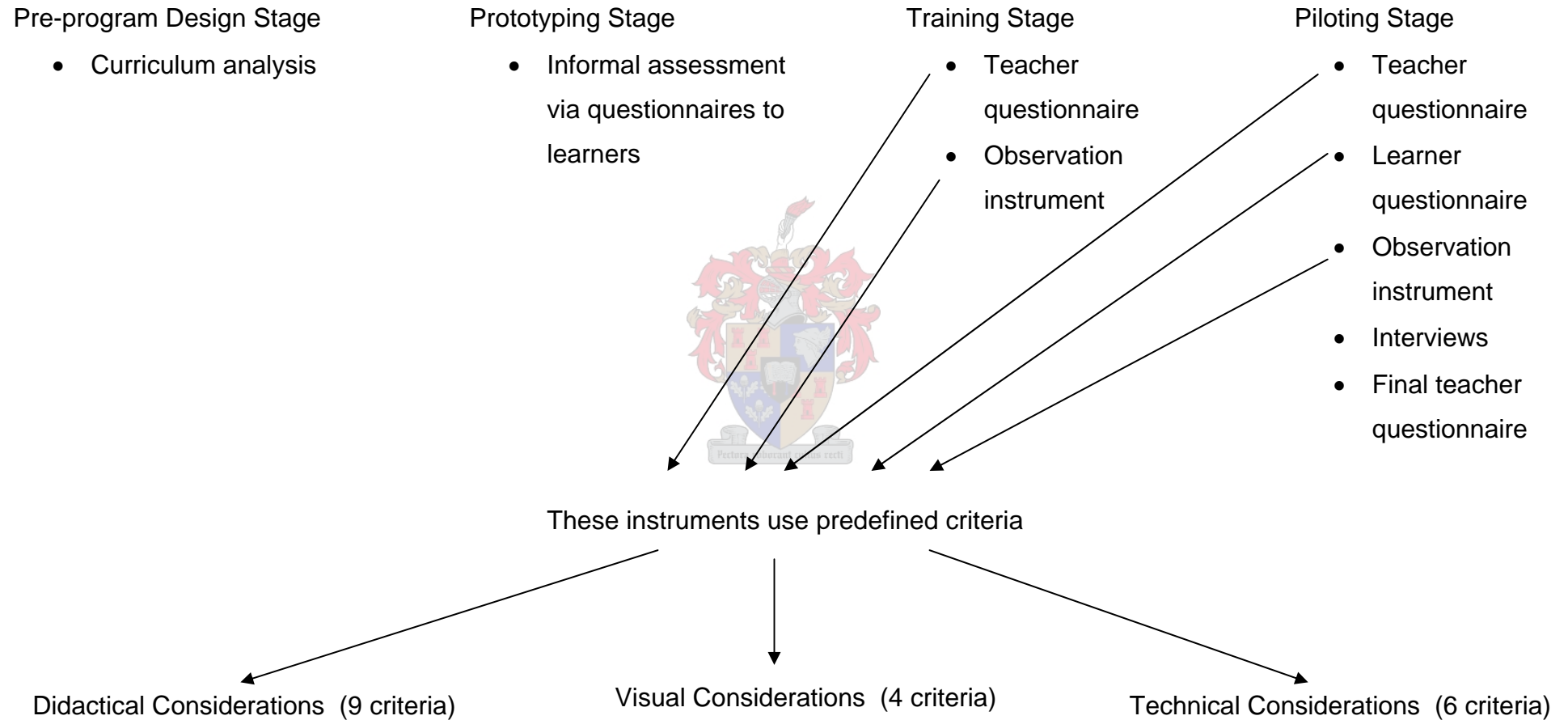
1. cost effectiveness;
2. effectiveness of training;
3. time needed to become comfortable with the technology;
4. technical support required during use;
5. effectiveness of providing in-service training to teachers;
6. ease of use and ease of navigation within the CAIR.

These criteria show that it is not only the CAIR that is evaluated, but also the process of implementing it in the classroom as well as the successes and pitfalls of using it as a resource.

The design of instruments to facilitate evaluation is reported in Chapter 5. The following page shows a schematic representation of the evaluation process in the different stages.



## The evaluation process



**Diagram 2**

## 2.3 Summary

In summary it can be stated that this study is underpinned by an interpretive philosophy that becomes apparent by the interpretive way in which data are produced through open-ended questionnaires, interviews and observation in an approach that Pham (1998: 119) calls the naturalistic approach and is focused on teachers' and learners' views and experiences. The choice of this approach relates directly to the nature of research questions 2 and 4 posed at the end of Chapter 1 (see p. 29). These questions are not concerned with quantifiable learning outcomes, but rather focus on the learners' and teachers' experience of the interventions.

The methodology is a developmental one that is based on rapid prototyping principles, incorporating an adapted Laurillard model to define different stages. This can also be related to research questions 1 and 2, which refer specifically to the development of the CAIR. To define the methodology in this way creates coherence between elements of the theoretical framework relating to developmental research, research questions based on the given theoretical framework and techniques employed in the empirical investigation.



## Chapter 3

# DEFINING PRINCIPLES FOR SOFTWARE DEVELOPMENT

## 3.1 Introduction

One may want to argue that the software design principles and technical aspects reported in Chapters 3 and 4 are superfluous to this dissertation. However, there are a number of reasons why this needs to be included:

1. It provides a record of the aspects that were considered and provides insight into my design preferences;
2. It provides a framework against which responses from teachers and learners can be assessed. This makes it possible for the reader and me to decide upon the validity of a given criticism or response;
3. I have experience of some of the departments at my school having turned down multimedia resources owing to unsatisfactory interface design or user-unfriendly navigation systems. It can therefore not be assumed that these principles are common knowledge, as it would seem that designers are not always aware of appropriate interface and navigational design that would be acceptable to the end user;
4. The content in Chapters 3 and 4 relate directly to research questions 1 and 2;
5. Chapter 4 reports on the technical difficulties that were encountered and how they were overcome. This may help other designers to not fall into the same traps and make the same mistakes.

Before identifying the principles for the development of the CAIR, it is necessary to consider the nature and functions of the CAIR.

This CAIR is not a tutoring-type programme that gives feedback to learners and interacts with them to help reinforce knowledge or introduce new principles. Instead, it should have the following properties:

1. It should be an instructional resource that aids the teacher in presenting new knowledge;
2. The printed version should also serve as a set of notes for students to study from;
3. The software must help inexperienced and under-qualified teachers to structure their lessons, while still giving them the necessary freedom to develop a personal teaching style.

In considering these guidelines on the functions of the software, each point can be considered separately to identify the underlying principles that would be fundamental in the developmental process.

### **3.2 An instructional resource**

The principles that would apply to this function would be the principles governing the design of good presentations. As these presentations would involve animation, video, sound and text, one would need to research the principles that distinguish good and effective layout from bad and ineffective layout. The Internet provides a variety of sources that offer advice on the design of software. In this part of the research, sites like Black (1997), Blau (1999), College of Agricultural Sciences (2000), Colorslide.com (2000), Humanities Electronic Media Project (2000), Lindsay, EB (1999), Psychology at Western (1998) and University of Pittsburgh, Department of Surgery (1997) were visited in search of common principles. The principles that were identified as well as principles derived from personal experience are reported in this section.

1. Keep the layout simple. This means that there should not be an overload of information and that one slide should present only a small portion of information. This also allows room for illustrations. The general guideline seems to be no more than ten words per line and no more than seven lines per slide. Information should not be crowded and spaces should be left open between lines of type. Text should be left aligned and not centred seeing that English is read from left to right.
2. Fonts should be large and should contrast with the background to make the text easier to see. Fonts sizes should range between 18 and 48. Experience has shown, however, that when projecting on a 74 cm television screen, one should not use a font size smaller than 32. When choosing a font, it is better to use one with no serifs. Serifs on the letters help the eye move from letter to letter on paper, but

tests have shown them to be a hindrance on slides. Arial is a good choice; Times Roman is a bad choice. It is better to use system fonts, as they will reproduce correctly on any machine. System fonts are: Arial, Times New Roman, Symbol and Wingdings. Do not use only capital letters, as they are hard to read.

3. It was found that in connecting a PC to a television via a so-called PC-to-TV video card, that there was still much flickering on the television, even if the flicker removal option in the software was set to a maximum. One way to solve this problem is to use dark backgrounds with light text. This almost completely solves the flickering problem. The ideal would, of course, have been to use digital projectors, but this would mean a huge capital investment in hardware as projectors were much more expensive than TV's at the time of this study. One could have opted for LCD panels on overhead projectors, but unfortunately these also come at quite a high cost and produce unclear images that require dark rooms as reported by researchers like Sammons (1995) and Luna and McKenzie (1997).
4. Colour should be used to emphasise and should be kept to a minimum. Use colours that contrast. In *How to Design Good 35 mm Slides* (Photographic Specialities 1999) it is stated that:

*With projected light, bright, light, warm colours seem to advance toward the viewer, while dark, cool colours seem to recede. Therefore, always use darker, cooler colours for your background and brighter, lighter colours for your text. The eye is most sensitive to yellow light, thus most people use yellow for their titles and highlighted, important text.*

In *Tips for presenting good slide presentations* the following advice is given on using colour:

*The best way to provide emphasis of ideas, points, bullets, words, phrases, paragraphs, and the like is with bold fonts, italic fonts, or different colours. Be careful though of red letters on a blue background or red green combinations. A surprisingly ineffective way to emphasize is with underlining.*

Avoid using background colours with gradients as this can cause perceptibility problems.

Pett and Wilson (1996: 25) report on a number of studies which indicated that learning did not improve due to the use of colour. It is reported, though, that the use of colour influences the affective meaning of pictures. They summarise this as follows:

*Research findings indicate that random use of colour generally is not of value in increasing learning, but it is preferred and does add interest.*

Pett and Wilson (1996: 28) also report on a study by Pastoor (1990) which concluded that colour did not have any real effect on performance as long as character size and contrast were set for adequate legibility. Pett and Wilson (1996: 30) emphasise this point by remarking that size is more important in lettering than colour. It should also be remembered that many people are colour-blind to some extent. It is possible, however, to enhance some effects by choosing colours carefully. They make the following suggestions:

*... colour will appear to be of higher saturation when seen against a background of its complementary hue (e.g. yellow on blue) than when seen against a background of similar hue (e.g. yellow on red). Reds and oranges seem to advance and blues and greens seem to recede. Colours at the end of the spectrum, red and violet, seem to result in greater arousal, and colours in the middle of the spectrum, yellow, green, cyan, seem to be the best for discriminating detail.*

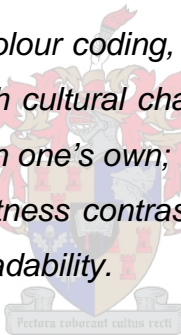
It is therefore suggested that blue and cyan are good background colours and that red and yellow are good colours to highlight information.

It seems that colour can be used effectively to focus the attention. Wu and Dwyer (cited in Pett and Wilson 1996: 26) mention that colour used in print can help the learner to focus on central information and thereby reduce the time it takes to process information when used in conjunction with oral instruction.



Pett and Wilson (1996: 29) give the following guidelines for using colour for CRT (cathode ray tube, e.g. computer monitors) presented materials:

- *Use a maximum of four to six colours per screen;*
- *Be consistent in general colour choices throughout a program section. Be especially careful to be consistent in colour coding;*
- *Use colour to link logically related information;*
- *Avoid combinations of complementary colours that are the same value, such as blue/orange, red/green, and violet/yellow unless used with extreme discretion;*
- *Use brighter colours for the most important information;*
- *Use colour to highlight errors;*
- *Use of a range of greys to provide a neutral background for two or three other colours;*
- *Use commonplace colour coding, such as red for stop, green for go, and so forth, but research cultural characteristics for colour use in designing for cultures other than one's own;*
- *Use significant brightness contrast between text colour and background colour to increase readability.*



5. Be consistent in the design so that special effects will stand out. Use a template that provides the general layout and design for a slide show. If there is a logo on a slide, it should appear in the bottom right-hand corner.
6. Use images and sound sparingly as they use a lot of system resources. Images and sound should be relevant to the presentation and must only present the concepts that need to be presented. Don't use more than two graphics per slide. Goldsborough (1999) says that multimedia effects must be used sparingly. Animation and video must be used to illustrate and highlight. Excessive use seems amateurish. It is also suggested that images should be placed to the left of text or above text.
7. Rieber (1990: 135) argues that animation offers the opportunity to effectively represent motion and trajectory in physics instruction. He remarks though (*ibid.*:

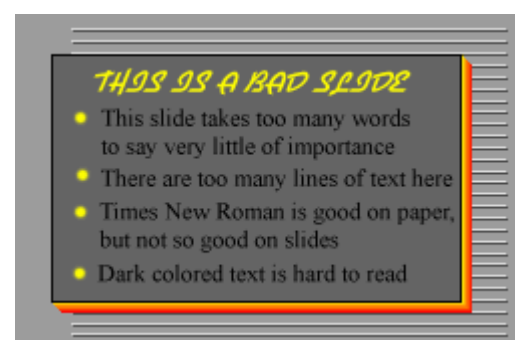
139) that animation should be used in conjunction with supportive activities such as practice.

Park (1998: 38) states that animation can be used effectively to teach abstract and dynamic concepts in Physics. He mentions Newton's Laws as an example. He attributes the helpfulness of animations in understanding concepts like velocity to the fact that direct observation of dynamic concepts in the movement of actual objects is very hard. He lists the following instructional roles of animation:

- a. attracting and directing student attention;
- b. representing movement;
- c. explaining complex knowledge such as structural and functional relationships.

Park (1998: 47) also suggests that static graphics with motion cues could be used as an alternative to graphic animation. He prefers animation, as ... *it may be easier for learners to understand the dynamic attributes of the task from direct observation of the animated simulation than to infer them from motion cues in static graphics.*

How to Design Good 35 mm Slides (Photographic Specialties 1999) gives the following examples of good and bad slide design:



**Figure 1: Examples of good and bad slides (1)**

Colorslide.com gives the following two examples:



**Figure 2: Examples of good and bad slides (2)**

### **3.3 A set of notes to study from**

In applying the principles mentioned above in developing instructional software, one should remember that one is not only presenting a lecture to inform an audience. Students have to be able to study from the material. This means that information could sometimes become cluttered on the slides, as students need to be presented with all relevant information and not just the highlights. It is necessary that teachers should be aware of this when presenting slides and should not rush through slides that contain much information. The need to provide notes that are similar to the slides is supported by the research results of Mayer and Coleman (2000: 5). They made their slides available for download off the Internet and found that the majority of students downloaded the notes before class to use as a template for additional note taking. More time needed for note taking was also one of the issues mentioned in articles by Sammons (1995) (see p. 12) and Luna and Mckenzie (1995).

In printing out the slides on paper one has to bear in mind that animation and video will be lost. It is best therefore to provide a printed version with an image that would remind the learner of the particular animation or video (remember a picture paints a thousand words).

Another consideration is how much information to put on one page. I used Microsoft PowerPoint slide shows before developing the format for dissemination via the Internet. The PowerPoint format provided different printing options. It was found that printing six framed slides per page gave a very structured layout to learn from. Learners generally gave positive comments in informal interviews and said that it was easier to study from than normal textbook-type printed text. It was also found that six slides per page often resulted in images being too small and some text (especially labels in diagrams) would be

hard to read. It is my opinion that it would be better to have no more than three slides per page and that one should be careful in printing this that the aspect ratio of the slide is retained (i.e. make sure that the slide is not distorted by stretching, say, the width more than the length).

It was also found that students need some space to write in if extra examples are given in class or if they want to make a note on something. It is therefore advisable for the printed versions to have blank pages next to them.

It is also advisable to have a slide with questions in the printed version after every few slides. These questions should be simple ones that focus on basic theory covered that would help to focus the learner's attention on core concepts. The answers must be available in the previous slides and students can use the blank pages to answer the questions on.

Typical examples of exam-type questions are also needed and should be provided by the teacher in conjunction with the CAIR. This makes it possible to discuss such examples in class and it helps learners to recognise the context of problems when they encounter them in tests or exams.

All of the above principles may seem obvious. Experience and informal interviews with students have emphasised the importance of these principles to me, which is why this study would not be complete without reporting on them.

### **3.4 Structuring the lesson**

This section juxtaposes the contribution that multimedia presentations could make to the structuring of lessons and the effect of the reality of the South African situation, and this research situation, on that ideal. In the light of this discussion the principles that were given consideration in the deployment of content within the CAIR are presented by referring to specific examples from the developed CAIR.

#### **3.4.1 The contribution that multimedia presentations could make**

Hannafin *et al.* (1997: 104) identify five foundations in the design of learning systems. These foundations are: psychological, pedagogical, technological, cultural and pragmatic.

According to them, psychological foundations that represent beliefs about how individuals think and learn are inextricably bound to pedagogical foundations that emphasize the representation of and supporting structure for material to be learned. They describe the effect that cultural foundations have on the design of learning systems as defining the contextual values of the situation. Here they mention the growth of technology in education systems as an example of a contextual value that reflects the cultural belief in the increasing importance of technology in society. On reflecting on the use of technology in terms of the identified foundations with a view to designing learning strategies, Hannafin *et al.* remark that the technology is valuable because of the influence it has on learning, not just because it is available. The rapid growth of its use in educational systems also reflects the importance of the role of technology in our everyday lives. They also point out that pragmatic foundations reflect practical concerns such as the influence that hardware and software type and cost have on the adoption and diffusion of innovations.

If one applied the five foundations of Hannafin *et al.* to this study, one would notice that cultural, technological and pragmatic aspects have been addressed in sections 1.2.2 (see p. 9) and 1.2.3 (see p. 13). The role that psychological and pedagogical aspects could play in structuring the lesson needs some attention in this section.

The nature of the content to be taught influences the choice of the principles of learning theory that one would employ in structuring a lesson. Different learning theories address different issues in learning. This view is supported by Rieber (1993) (cited in Hannafin, Hannafin, Land and Oliver 1997: 114), who reports on an example of a learning system that applied the principles of constructivist and instructionist epistemology in the learning of Physics. Hannafin *et al.* (1997: 114) warn that:

*Simply labelling an activity as instructional because it is objective-referenced does not constitute grounded instruction; likewise a given activity cannot be reconciled as constructivist simply because it is student directed.*

Petraglia (1998: 63) discusses the use of educational technology in designing constructivist learning experiences. He agrees that ... *technology augments the educator's ability to enrich learning environments in ways scarcely imaginable only a decade ago.* He also warns that technologists should be careful about making claims

about the authenticity of tasks and relevance to everyday life situations simply to gain acceptance for the constructivist nature of such programmes.

It has to be realised that the CAIR will be used for the initial introduction of new knowledge to learners. It is acknowledged that learners will enter the classroom with preconceived ideas and that these ideas will often conflict with the scientifically accepted interpretation and meaning of concepts. This phenomenon therefore leaves the teacher with the problem of having to facilitate the change that has to take place in the learners' minds. A useful tool in this process is the conceptual change model suggested by Posner, Strike, Hewson and Gertzog (Posner *et al.* 1982: 214). According to this model conceptual change could take place when:

1. there is dissatisfaction with existing ideas;
2. the new conception is intelligible;
3. the new conception is plausible;
4. the new conception is fruitful.

One possible strategy that actively involves the learner is to present him/her with the opportunity to make predictions. These predictions can then be challenged by confrontation with an observation or another argument. The learner then needs to decide if this causes a conflict with his/her initial prediction. If a conflict exists the learner must explain why and identify a strategy or explanation to resolve the conflict. This predict-observe-explain (POE) strategy not only puts the learner on centre stage in the learning experience, it also presents an opportunity to facilitate conceptual change.

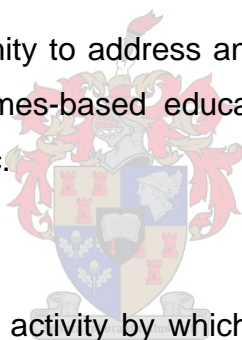
Multimedia presentations provide an opportunity to employ relevant epistemological principles by structuring presentations accordingly. When teachers use these presentations in the classroom, there is an opportunity for them to learn about teaching through the way that the presentations are structured. This means that knowledge gained by research done in various areas of Physical Science does not need to be hidden in somebody's dissertation on a library shelf anymore. It may be true that a fair amount of the knowledge gained by research is reported in subject literature, but it is questionable if this knowledge ever reaches the teacher in the classroom. Multimedia presentations now also provide the opportunity to make use of such information when designing the presentations. Teachers then get the benefit of using a structured lesson plan that has been designed by experts.

An example of how one could, for instance, incorporate the principles of modelling in the design of the resource can be found in the teaching of density in Grade 8. To make it easier for the reader to identify the modelling strategy in the design, it may be helpful to also present an alternative strategy that does not employ modelling principles.

### **Approach without modelling**

The teacher lets learners experience different densities by providing them with different materials. After they have gained an understanding of the concept in terms of how tightly particles are packed within a substance, the teacher provides them with a formula for density. To reinforce this formula, the teacher designs an activity in which learners have to determine the mass and volumes of various regular and irregularly shaped objects. They then have to use the given formula to calculate the different densities and then need to identify the materials that the objects are made of from a table of materials and densities provided by the teacher.

This approach provides an opportunity to address and assess numerous skills and could therefore fit in well with an outcomes-based education approach. Compare it to the following approach to the same topic.



### **Approach with modelling**

The teacher gives learners a group activity by which they have to decide what the term density means. After feedback from the groups and a class discussion on the best description (facilitated by the teacher), the groups have to identify two measurable quantities that can be linked to density. After this process, learners should have identified mass and volume as the quantities.

The learners are then told to identify two materials at home with different densities and to find three objects of each material to bring to school. It has to be obvious to them which material is denser. Learners then need to determine the mass and volume of each substance. They are now asked to draw graphs of mass versus volume and volume versus mass for both materials on the same set of axes. They now have two sets of axes with two graphs on each.

Learners are then asked to identify the denser substance on each graph. They will, of course, now find that the denser substance is the steeper graph where they plotted mass



versus volume and vice versa for the graphs where they plotted volume versus mass. They have therefore now discovered that they can use graphs to investigate which one of the two substances is the denser. More than that, they have two ways of drawing the graphs and they have not yet seen a mathematical formula. Where computers are available, learners can be asked to do the graphs on a spreadsheet to help facilitate the acquisition of computer skills.

Learners are now given the task of finding a way to manipulate mass and volume mathematically to get a numerical value that could be used to label density. This process can be facilitated as follows:

A. Identify the denser object in the following table.

Object	Mass	Volume
A	20g	10cm <sup>3</sup>
B	15g	10cm <sup>3</sup>

B. Identify the denser object in the following table.

Object	Mass	Volume
A	20g	10cm <sup>3</sup>
B	20g	5cm <sup>3</sup>

C. Identify the denser object in the following table.

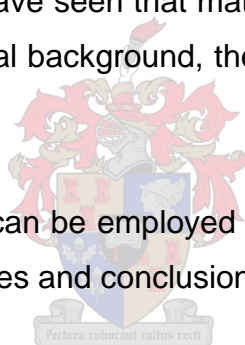
Object	Mass	Volume
A	5g	10cm <sup>3</sup>
B	15g	15cm <sup>3</sup>

Learners should realise through activities A and B that if the volumes are the same, the greater mass indicates the greater density. If the mass is the same, the smaller volume

indicates the greater density. In case C they therefore have a choice. They can either make the mass or the volume the same. Now it is up to the class to decide which method they like better. They have to justify their choice. The teacher has to lead them to discover that it is more elegant to make the volume the same, as the greater mass indicates the greater density. Now all that is left is to reach consensus to make the volume one unit of measurement for all calculations.

Learners are then asked to calculate the masses for A and B if the volume is one cubic centimetre. They then need to look at their methods to identify how they manipulated the mass and the volume to obtain their answer. It is always a magic moment when learners realise that the mass divided by the volume gives them an indication of the density. What is more important is the realisation that they had a choice and that the formula is therefore a man-made mathematical model to label density and not a law that was handed down by some higher intelligence to the teacher and then by the teacher to them. They have been part of the modelling process and have seen that mathematics is a tool in that process. If learners have sufficient mathematical background, the formula can now be related to their experience with the graphs.

The strategy presented for density can be employed in designing a presentation resource with all the necessary tasks, examples and conclusions that learners are guided towards.



The discussion in this section has so far presented opportunities that multimedia presentations provide for the employment of relevant psychological and pedagogical principles in the instructional design. One needs to ask how this ideal relates to the reality of the South African and more specifically this research situation.

### **3.4.2 The reality of the South African and the research situations**

Before this ideal presented above can be reached, one needs a teacher who is open to employing strategies based on learning theories that may be unknown to that teacher. One could represent the science teacher situation in South Africa as follows:



**Diagram 3: The current situation versus where we need to be.**

The block on the left of the diagram represents the majority of teachers as reported in Chapter 1 (see p. 3). The block on the right represents the type of teacher envisaged by the designers of the new curriculum as stated on p. 3 of the revised National Curriculum Statement by the Department of Education (2002). The arrow connecting the two represents the road we need to walk to improve the situation.

Unfortunately much of research done is aimed only at the teachers represented by the block on the right. These teachers may be able to benefit from interventions that make use of specialised strategies like POE strategies or modelling approaches. These teachers could then benefit from multimedia presentation packages structured according to, for instance, constructivist principles. Unfortunately, as Grayson has remarked (see p. 5), teachers in the left-hand block may feel too inadequate to incorporate such strategies into their teaching. If this study were to incorporate such strategies in the design of the CAIR, it may introduce an aspect into the intervention that could lead to its non-use by teachers exactly for the reason mentioned by Grayson. Teachers may then struggle to integrate the CAIR into their way of teaching. In Chapter 2 (see p. 48) a criterion has been identified that deals with integration of the CAIR into the structure of the lesson. To allow teachers with differing capabilities to use the CAIR successfully, one would therefore aim for flexibility in design so that teachers could use the CAIR in, for instance, instructionist and constructivist approaches.

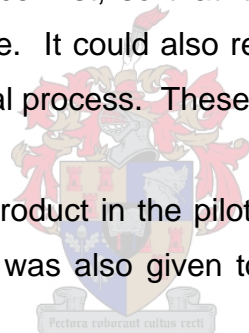
The question that we need to ask is how the ideal of incorporating specialised learning theory into multimedia presentation design above could be accomplished in the long run. The role of this study is to determine if multimedia presentation presents a viable alternative to what is currently happening in classrooms. If this study finds that it can work and that the problems that have been identified can be ironed out, then it would mean that

the Internet could be used as a vehicle to distribute the multimedia resources to teachers all over the country. Only once the results of this study have become clear would one be able to take the next step to develop resources for all the topics in Physical Science.

This would then give an opportunity to develop content according to the principles of open-content development described by Keats (see Chapter 2 p. 41). Science educators could then publish their resources on the Internet and quality could be controlled by a central clearing-house. All of these efforts would then contribute to the process of lending structure to lessons of under-qualified and inexperienced teachers, as the knowledge of experts would be shared by everyone.

Although this presents a rich opportunity to the larger teaching community, it would be irresponsible to simply start developing resources and presenting them as the panacea to the problems in education. That is why it necessary to test the use of multimedia presentations as a teaching resource first, so that it could be determined if the effort is pedagogically justifiably and feasible. It could also reveal possible pitfalls that could then be avoided during the developmental process. These issues define the focus of this study.

To ensure the testing of a quality product in the pilot schools for this study, the resource was tested in my classes first and was also given to other researchers and teachers to scrutinise.

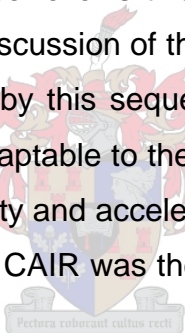


Having said all of the above, the principles for developing multimedia resources with the aim of assisting in structuring lessons are as follows:

1. Employ the principles of learning theory that are relevant to the nature of the content, if teachers have the know-how to employ such specialised strategies. Otherwise one may need to use a mixture of approaches, as advocated by Pham (see p. 47) to provide flexibility to teachers;
2. Make use of available research results and expert opinion in the developmental process;
3. Establish a central point (clearing-house) that would approve contributions by other teachers and ensure the correctness of the technical format.

The last point could, of course, only become a reality once the results of this study have been finalised. The CAIR was designed with a navigational system that gave the teacher enough flexibility to jump easily around between slides if he/she wanted to follow a different sequence of unlocking information (see section 4.4, p. 73). In this way teachers were not limited by the principles of any given learning theory with which they may not be able to identify. The content area that was chosen for this study is the area of Newtonian mechanics.

In the structuring of the sequence of content deployment, consideration needed to be given as to which concepts should be introduced first. Examples of how this was done can be found in various sections. For instance, vector addition and resolving vectors into components are introduced before discussing forces in equilibrium and objects on a slope. In the section on velocity and acceleration the problems relating to velocity and relative velocity are discussed before calculations with acceleration using ticker tapes are introduced. The section on graphs also follows this section, so that definitions of velocity and acceleration can be used in the discussion of the relationship between various graphs. The inexperienced teacher is guided by this sequence of content deployment, but some teachers may need the CAIR to be adaptable to their preferences, for example, some may want to introduce the section on velocity and acceleration before introducing the section on force. The navigational system of the CAIR was therefore designed to provide flexibility in content deployment.



### 3.5 Technical Considerations

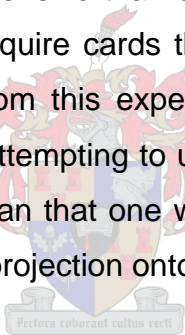
The principles that have been defined in this chapter are all principles relating to the functionality of the CAIR for both the teacher and the learner. There are some technical considerations that also have to be addressed. These have to do with the software used to develop the resource, the format of the resource and technical difficulties that had to be overcome to make the resource user-friendly.

These issues are addressed in the following chapter. Two constraints require some attention at this stage. Both of them involve technical issues surrounding hardware.

### 3.5.1 Financial constraints

This study was undertaken with financial support from TRAC South Africa. This meant that schools that already had TRAC systems available in the classroom could be used as project schools. This saved on costs of the PC. Images from the PC needed to be transferred to a TV screen. This meant that all the PCs had to be fitted with PC-to-TV cards and s-video cables to connect the PC to the TV. Classrooms also had to be equipped with TVs.

All project schools were therefore equipped with 74 cm TVs. Different PC's were found to be using different types of technology. This meant that in some cases the PC-to-TV card had to be plugged into the motherboard of the computer using a PCI slot. This represents technology that is somewhat older than the newer AGP slots that some other motherboards have been equipped with. Two different types of PC-to-TV cards therefore needed to be acquired. It was found that PC to TV cards that made use of the older technology (PCI slots) were more expensive than cards that made use of the newer AGP slots. It was also more difficult to acquire cards that made use of the older technology. The important lesson to be learnt from this experience is that one should avoid using technology that is old or outdated. Attempting to use old hand-me-downs from, let's say, businesses for this purpose could mean that one would find it difficult or even impossible to obtain the necessary hardware for projection onto a TV screen.



The TRAC computers were also not equipped with sound cards or speakers. There were also no Internet connections in the classrooms. This meant that the CAIR needed to be developed without sound and without links to the Internet due to financial constraints. Although this placed a limitation on the possibilities that the CAIR could offer, sound and Internet connections were not requirements to investigate the issues relevant to this study.

### 3.5.2 PC performance constraints

Computers from different schools had different specifications. The CAIR needs Internet Explorer 4 or higher to run. This needed to be loaded onto all the computers. All the computers were found to handle the CAIR easily. It was found in one school that PC speed was a problem. It is therefore recommended that one would need at least a Pentium I processor supported by at least 64 M RAM, although 128 M RAM is preferable. Although the CAIR runs on slower computers, a slow computer causes slow slide transitions.

## Chapter 4

# TECHNICAL ASPECTS OF THE SOFTWARE DEVELOPMENT AND MECHANICS OF THE TRAINING PROCESS

### 4.1 Introduction

The challenge in developing instructional software is that the task is multi-dimensional. Some of these factors have been discussed in the previous chapters. When one has identified the evaluation criteria and the development principles, the challenge becomes putting all this into practice. This involves considerations of a more technical nature. In this chapter the choice of development software will be discussed as well as the difficulties that had to be overcome to make the instructional programme perform in the desired way.

The chapter is concluded by presenting the mechanics of the training process.

### 4.2 Choosing the development software

It is necessary to define what is meant by development software first. When one needs to type a letter, one would use a word processor to perform the task and then print it, or the letter could be typed using an e-mail client (the client is the e-mail software that is used), or the letter that was first typed in the word processor could be attached to an e-mail and then sent to the recipient. If the letter is printed, the person reading it needs only the hard copy to be informed. If one sends an e-mail message, the recipient needs an e-mail client to receive and read the letter. If the letter is sent as an attachment, the recipient would need an e-mail client as well as word-processing software to read the letter.

The example above shows that there are different options when working with software. The option that one chooses would depend on one's needs. If one wanted to incorporate a little video clip into the letter, it would be pointless to send a hard copy, and it could be hard to find an e-mail client to do the job. In such a case it would be better to use a word processor to create the letter and then attach it to an e-mail message. The recipient would



then be required to have a word processor and media player (for the video) on his machine to view the letter and video. Although this example may seem artificial, it is relevant to this study as it identifies some of the challenges on a simpler level.

If one now considers the example, it becomes clear that the development software would be the word processor or e-mail client or whatever text editor one chooses to use. The e-mail client, however, also serves as an interface to facilitate the sending of the letter.

To choose the appropriate development software for this study was a little bit more complicated than the problem of having to send someone a letter. The following list identifies some of the properties of the final product that needed consideration:

- The teacher has to be able to control it;
- It has to have the capability of playing animations and video clips;
- It has to be easy to navigate even if the teacher is not a computer expert;
- One has to be able to print it out as a hard copy for the learners to study from;
- The teachers' use of the software must not put the software at risk. In other words, the teacher should not be able to accidentally delete or move files to wrong folders and therefore change aspects that are crucial to the operation of the software. This is of particular importance in this study, as there is a low PC literacy level amongst teachers in the Western Cape (see p. 22 –23).

One could of course employ a programmer to develop a package that would do the job. The high cost involved and the fact that an expert now needs to do the development means that it could become impractical from a cost point of view. It would also mean that such a process could be very time consuming, as the programmer would have to liaise with a subject expert to ensure the appropriateness of content deployment. As there are some editors (development software) around that could do the job, it is necessary to consider some of the possible alternatives.

There are a number of presentation packages around. Corel offers Presentations, Microsoft offers PowerPoint and Sun offers Impression. All of these are presentation type editors that would help one to create slide shows. They all have the capability of being integrated into so-called office suites that make them interact well with other image-editing software, word processors, databases and spreadsheets.



In 1997 when I started developing presentations for class use, different options were investigated. Even though I used the Corel Perfect Office Suite at that stage, I opted for Microsoft's PowerPoint as it offered more animation options. In the two and a half years that it has been used, it has served me well. It has a few limitations, though, if it were to be used by teachers who are not necessarily expert users.

A player is available for users who do not have the PowerPoint software installed on their PCs. Unfortunately it does not always represent videos and animations properly and causes some other technical difficulties during installation. This could mean that schools would need to purchase the PowerPoint software. Although some schools may be able to afford this, it creates a further problem for the inexperienced user. As PowerPoint (like most other presentation editors) opens a presentation in an editing window from which it can then be started, it creates a risk that the teacher may unknowingly and accidentally change some things. The teacher may then not know how to reverse the changes. I have experience dealing with this problem in one of my previous schools. I was asked on a number of occasions to restore presentations that had unknowingly been altered by inexperienced users. This could result in a nightmare situation as far as support is concerned. If the player had worked flawlessly, this problem would have been solved. Readers may find it interesting and somewhat amusing to know that at the school where I am currently teaching, teachers regularly manage to delete shortcuts and files that are crucial to the working of the e-mail client from the networked computers. It remains a mystery how they manage to accomplish this, but it is one of the reasons why technical support needs to be on hand. Protecting software from accidental changes where inexperienced users are concerned is therefore a very real concern.

In November 2000 I learnt that Sun Microsystems was offering their Star Office Suite for free, downloadable from the Internet. In order to test the Impression software (the presentations editor) the software was downloaded and installed. The capabilities in terms of animation and graphics were impressive. Unfortunately the software was quite demanding in terms of system resources, since it needs 64 MB of RAM (random access memory) to function smoothly. The first impression was that it could work very well as it was free and generally offered more than the other available options. The player was subsequently also downloaded to test how well it would work. However, the release notes (a set of instructions and information that is displayed at the start of installation) clearly stated that the player could not display OLE objects. In layman's terms this means that a

video clip, for example, cannot be viewed as it can only be inserted as an OLE object. To make sure that nothing was being overlooked Sun's support at Oakdale in Cape Town was contacted on 4 December 2000. They subsequently confirmed that the release notes were correct and that the player would not perform as had been hoped. That meant that one would have the same problems and risks as with PowerPoint with the added problem that Sun's recommendations were quite taxing in terms of system resources.

Because of all the above-mentioned problems it was decided to investigate another option altogether. This option was to use a format that would make use of a web browser to display the information. One may want to argue that one could simply have saved the PowerPoint files as html files. The problem is, however, that this creates very big file sizes that are laborious to download off the Internet. At the time that I was investigating these options, there was no way around this. Since then Powerconverter has been developed (for a discussion on this see p. 187) to solve this problem, but unfortunately it was not available at the time that I started this research.

### **4.3 Researching and developing a CAIR for dissemination via the Internet**

To understand the attraction of developing a CAIR for dissemination via the Internet (referred to as a web-ready format hereafter), one has to consider the reason for wanting to use the Internet again. If one can use the Internet as a communication highway to deliver instructional resources to teachers, it would be favourable to have a website where teachers can access information on these resources as well as examples of what the resources look like. If the presentations could perform on the Internet exactly the same way they would in the classroom, this would mean that sections of the finished product could be posted directly on the Internet without modification to serve as examples.

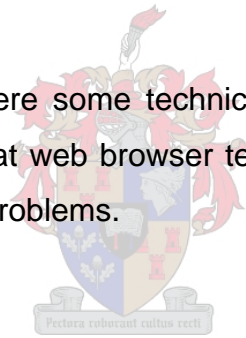
The web-ready format makes it possible to create animations that would be relatively small in file size. By using Macromedia's Flash, one could create animations and save them in a Shockwave format that can be viewed in any browser with the shockwave plug-in. This format has become a standard on the Internet and many browsers now have these plug-ins on installation. To obtain similar results in, for instance, a PowerPoint presentation, one would have to create the animation and save it in an animated GIF format. The file sizes are much bigger than the Shockwave format and would therefore result in longer download times over the Internet.

Web browsers like Internet Explorer and Netscape Navigator are freely downloadable from the Internet. The schools would therefore not need to incur any extra cost for software. The html files that would be created to produce the presentations are also much smaller than similar files in other formats, meaning that one saves on download time again. In South Africa, where we pay for telephone calls per minute, these cost factors need to be considered.

One would also not need a computer programmer to produce the final result. With html editors one now hardly needs to know any html to create web pages (html is hypertext mark-up language, a language that uses tags to create pages that can be viewed by a web browser).

Having considered all the advantages above it seemed to be a good idea to at least investigate the possibility of creating html documents that would perform as presentations in a web browser.

It soon became clear that there were some technical difficulties that would need to be addressed. Luckily it was found that web browser technology had advanced to the point where it offered solutions to all the problems.



#### **4.4 The interactivity and navigation problem**

Although one of the strong features of web sites is that they are said to be interactive, the nature of that interactivity is somewhat different to the desired interactivity for presentations.

Web pages make use of so-called hyperlinks to connect different pieces of information. The user then has the option to be taken to that information by clicking the relevant link. By clicking a link, the user is either taken to a different page or to a different position on the same page.

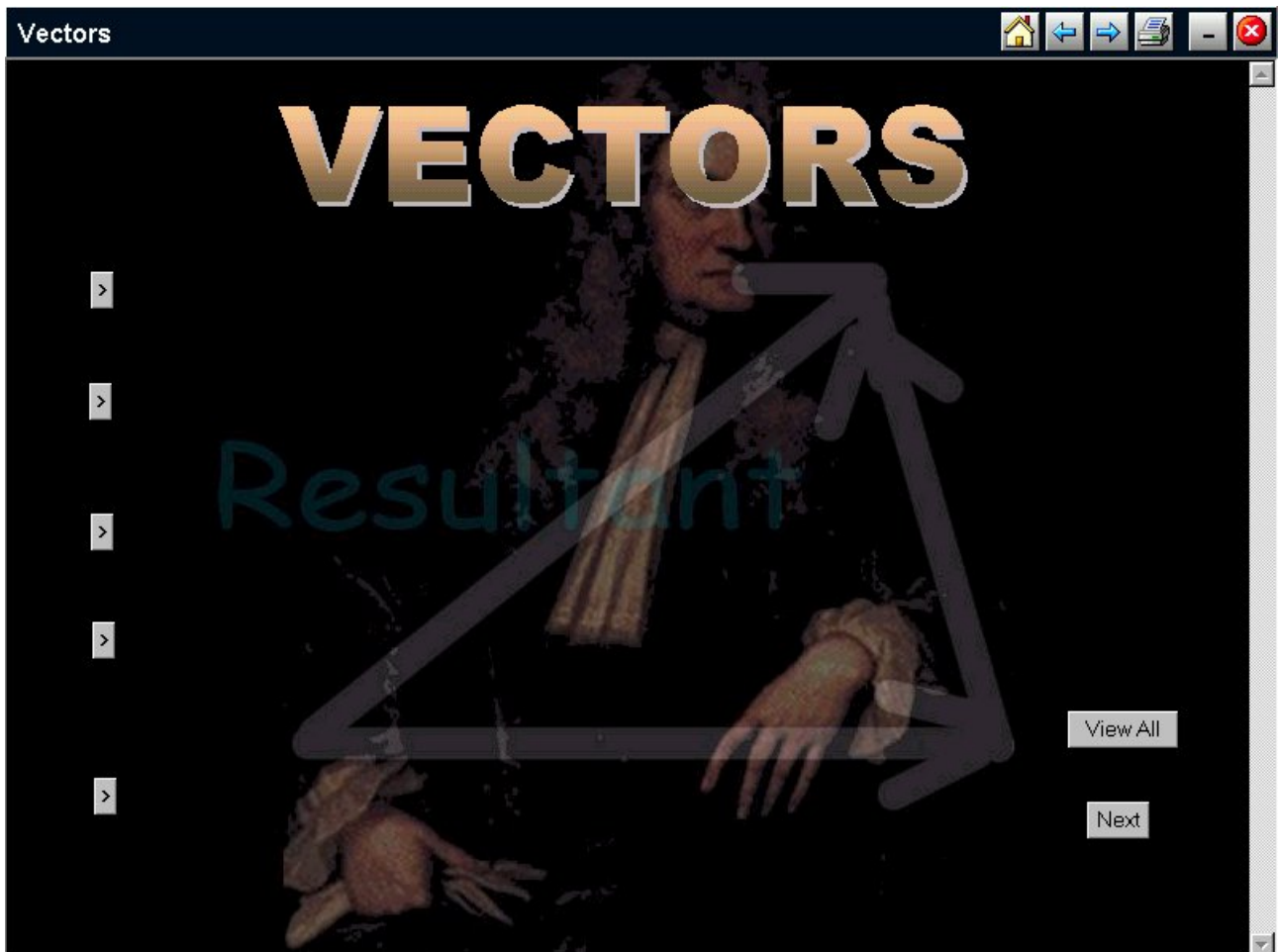
Presentations, on the other hand, require a new action to take place (like an animation to be played) or a new piece of information to be displayed when the mouse is clicked. This clicking of the mouse during a presentation can happen with the cursor anywhere on the

page whereas a web browser requires that a specific word, or sentence, or image, or icon need to be clicked to go to a next page. This led to three difficulties.

1. How does one tell the browser to simply display a new image or paragraph on the next click and not to go to a new page?
2. How does one tell the browser what the next piece of information is, without letting it go to a totally new page?
3. How does one determine where to click so that the browser would display the next piece of information?

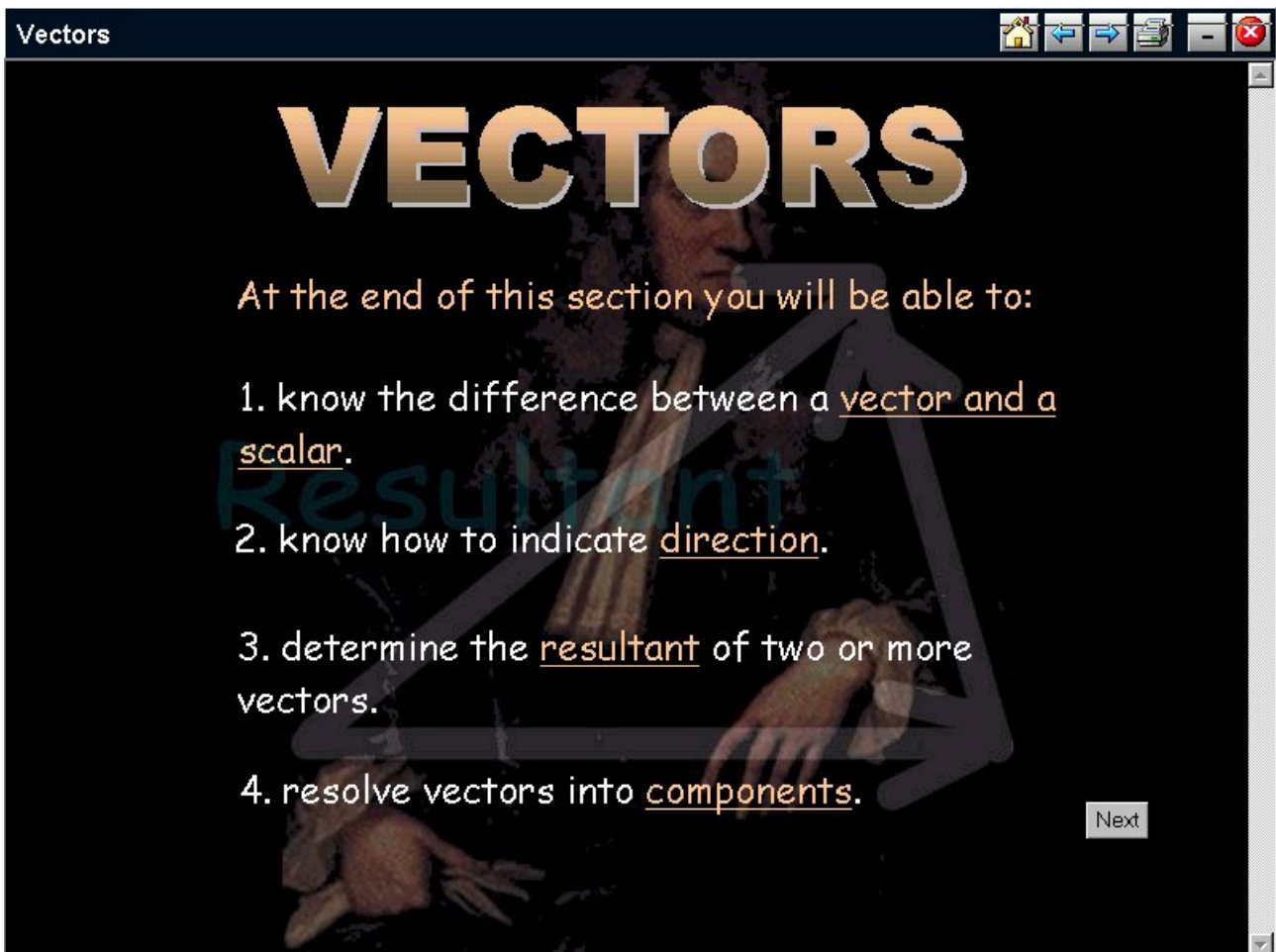
The first two problems were quite easily solved by making use of functions available from fourth-generation browsers onward. The function is called layering and makes it possible to have different layers on the same page. It is possible to have some of them visible and others invisible and to change that visibility at the next event. Such an event could be when a link is clicked or when a certain amount of time has passed. This can be done by the use of timelines. It was decided that one would not want to time the events (this is also possible in normal presentations using software like PowerPoint or Impression) as this would take control out of the teacher's hands. The timing of the next event would surely depend on when the teacher is ready or has decided that the learners are ready for the next piece of information to be displayed. This meant that the teacher needed control over the timing of events and that this had to be determined manually. The only option therefore was that the teacher needed to click the mouse for the next event. On a mouse click the layer containing the next piece of information would therefore become visible.

That solved the first problem. To solve the problem of informing the browser what the next piece of information is, a system was designed whereby one would click on an icon. A series of arrows would be present on the page when first viewed. Each arrow would be in its own layer. When an arrow is clicked, its layer becomes invisible and it makes visible another layer with the next piece of information. The following illustration shows what this prototype looked like.



**Figure 3: Example of first prototype web-ready slide**

This image shows the first slide before anything has been clicked. The arrows on the left side are clicked to reveal the next piece of information. An option is also built in to view everything at once (see the “View All” button on the right). When all the arrows have been clicked the next slide would need to be revealed. This could be accomplished by clicking the “Next” button on the right. When all the layers on this slide are revealed, the slide looks as follows:



**Figure 4: Example of first prototype web-ready slide with layers revealed**

This image shows the revealed layers. As this slide is the first slide of the presentation, it shows that one has an option to go either to the next slide or to the start of any one of the four sections in the slide show by clicking on the underlined word(s) (e.g. direction in number 2).

This prototype failed on the following issues though:

- It was not easy to navigate as one had to aim at a specific icon to reveal the next layer. Other presentation software makes it possible to aim and click anywhere (outside a video clip or animated GIF) and still effect the necessary change;
- There was no way for the teacher to navigate to any slide in the presentation. If the teacher therefore ended the previous period on a slide that was somewhere in between the slides to which the links navigate, he or she would have to click through a few slides the next day to start the lesson off where it had stopped the previous day.



The first and second problems (see p. 74) were solved, but the solution to the third one failed. To find a new solution one had to consider what the browser would react to. A mouse click would trigger the next event if the mouse were clicking something like an image, a sentence or an icon. The mouse had to be on the object when clicked. This was necessary to make it possible for web page designers to put many links on one page and to give the user the opportunity to decide which link to go to next. This offers enormous opportunities when wanting to develop interactive software that a learner will use on a one-to-one basis. When one thinks of presentations, though, the sequence of events can be predetermined and the teacher must not be bogged down by having to aim at and click on something specific.

The solution to the problem lay in something called a transparent GIF. A transparent GIF is an image format that allows for certain sections to be made transparent. The background would then shine through, making it possible to see what lay underneath. The format is often used by web designers when placing images on a page while still retaining the background image of the original page. What one needed to do then was to insert a transparent GIF (with nothing in it) into a layer and paste it over the whole page. As the browser now sees an image, it means that the image can be made clickable and that the page can be clicked anywhere. Different layers can be assigned different positions in the order. If one tells the browser that the transparent GIF that was just clicked becomes invisible after clicking, this makes it possible to make the next transparent GIF below it appear so that it can be clicked in turn. Every time the mouse is clicked, three things happen.

1. The layer containing the transparent GIF being clicked becomes invisible.
2. The layer containing the next piece of information becomes visible.
3. The next transparent GIF in the layer below goes to the top (as the other one has become invisible) and therefore becomes clickable.

The html document then functioned exactly like a PowerPoint presentation. The file sizes were smaller, though, and could be viewed in a fourth-generation or higher browser that is available free of charge. There was still one problem to be dealt with. The finished slideshow, with many html files, had to be protected from teachers moving or deleting necessary files. This could be done by using a tool known as a web compiler or html compiler.

A web compiler is a piece of software that takes all the files in a web page and compiles them into a single executable file. There is therefore only one file, which cannot be tampered with. There are different products available. Eight of them were downloaded off the Internet and tested. They are webexe, web2exe, hypermaker, e-book, html2exe, webgroove, icourier and mediapacker. Only mediapacker was found to work perfectly with the layer configuration of the presentations.

It has to be noted that mediapacker uses Internet Explorer to run the presentations. One does not always realise this, as the interface can be adapted according to personal preference. The presentations would therefore still need Internet Explorer on the machines in order to run. As Microsoft has made Internet Explorer downloadable for free, this does not constitute a problem. It would have been more acceptable if it could run using other browsers as well. It was found, though, that this would not work. Although some of the other compilers come bundled with their own browsers, it was found that they could not interpret the use of layers efficiently enough.

After all these problems had been identified and solved, one extra feature was added to the design. It was mentioned earlier (see p. 77) that teachers had a problem navigating to any slide. The first slide was redesigned, making it possible for the teacher to navigate to any slide. There would therefore be links from the first slide to any slide in that presentation. This meant that links had to be added to make the navigation possible. One could reason now that the teacher would have to click on something specific again. Although this is true, it would only be true for the first click of the lesson, when the teacher has to navigate to the slide where he/she left off the day before. It also compares favourably to other presentation packages that make use of little drop-down menus that are sometimes even harder to negotiate. The first slide of the vector presentation now looks as follows before anything is clicked (the background has since been changed).





Figure 5: Revised prototype slide

After all the information has been revealed, it looks as follows:

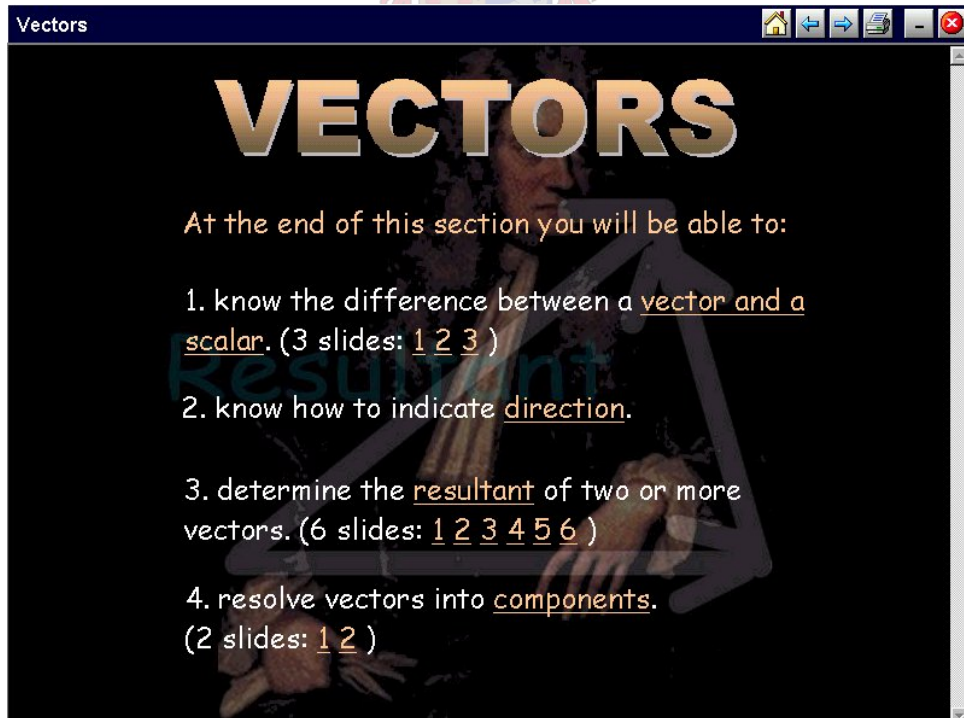


Figure 6: Revised prototype slide with layers revealed

Note the navigation bar at the top and the colour of the bar. These are features that can be customised according to personal preference. The features that are present in these images allow the teacher to go to Home (the first slide from which any other slide can be reached) to go forward or backward, to print, and to minimize and close the presentation.

One may ask if anything has been lost in this process that other presentation packages provide. The only thing that is really lost is the easily programmable transition effects which make it possible for images to appear by, for instance, flying from the top or bottom or left or right, or by zooming in or out, or by dissolving, etc. Although these effects can be very entertaining, they do not seem to add any real value to presentations. If anything, they seemed to distract learners rather than focus their attention. Sammons had also reported that students felt these effects should be minimised (see p. 12). These effects can still be programmed into the web-ready format, but it seems unnecessary as it is tedious to accomplish and is more taxing on system resources (like RAM). It was therefore decided not to include these effects in the final design.

#### **4.5 The font-size problem**

To make the text large enough to be read by learners in the back of the classroom, it was decided to choose a font size of 24 points (size 6 in some html editors). The font size was set while developing the slides using html codes. Other font attributes, like colour and font face (the type of font e.g. Arial or Times New Roman) are also set using html codes.

It has to be noted though that the compiled slide show uses Internet Explorer to be viewed. It is possible to choose default font settings in this browser. One would, for instance, choose always to view all fonts as Times New Roman and in blue. This is up to the user to change. When designing the slide shows, one needs to bear in mind that text may not appear the way that one wishes it to, if the browser settings for fonts are not overridden. As html codes override the browser settings, it is therefore simply a matter of specifying font attributes in html when creating the slides.

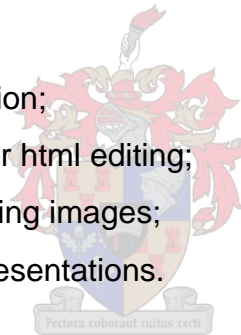
There is an added difficulty. Even if one specifies font attributes using html codes, there is a browser setting for font size that will override the html code. This is found in the View menu under Text Size. This is a feature of the browser that makes it possible for people with weak eyesight to view text larger than normal. This poses a problem for the CAIR as

these settings will influence the way the text is displayed and ultimately some text could overlap, or the layout of the page may not fit onto the monitor. To prevent this from happening, the browser setting has to be overridden. As this is not possible with html codes, another plan had to be made. The answer lay in the use of cascading style sheets (CSS). The code is simply overridden by creating a style sheet (a normal text file that is saved with a .css extension) that contains the necessary font size. Each slide is then linked to the style sheet and font sizes are not specified with html code as this would override style sheet settings again. This is a valuable point to remember. I did not realise this when the slides were initially developed. This meant a considerable amount of work was required later on to correct the problem.

## 4.6 The developmental software

The following software packages and editors were used to develop the instructional software:

- Paint Shop Pro for imaging;
- Macromedia Flash for animation;
- Macromedia Dreamweaver for html editing;
- JPEG optimiser for compressing images;
- Mediapacker for compiling presentations.



These packages were chosen as they were found to be user-friendly with help files that made it easy for a self-taught developer to get on with the job. I acknowledge, though, that there may be other packages that would perform the task with equal ease and that the choice is ultimately a personal one.

## 4.7 Developing a printable format

Although the navigation bar at the top of the slide does offer the option to print the slide, this would result in only one slide printed per A4 page. This would inevitably lead to a waste of paper and unnecessarily large print. There is unfortunately no option to print more than one slide per page (as with other presentation packages). A printable version of the CAIR therefore has to be prepared. Although this may seem time consuming, it is a reasonably simple process that can easily be handled using imaging software and a word processor.

For this study Paint Shop Pro and Microsoft Word were used to develop a printable version. The process involved the following:

- First the slides had to be captured as images, using the capture function in Paint Shop Pro (one could also use the print screen option and resize in the word processor). This turned each slide into an image that could be placed in a Word document. The images were saved in the jpeg format;
- Images were then resized to 50% of the original size;
- Three images were then placed on one page in a Word document with questions after every few slides by which the learner could test his or her knowledge of what had been read.

The slide shows were then organised in MS Word documents, where each document would completely cover one section of the work. All the Word documents together made up the whole of the Mechanics course for Grades 11 and 12.

The following page gives an example of such a printed page. It was felt that it would be better to print a negative image of the slides, as it would save on toner for copying. The backgrounds were not black, but actually were images made for every slide show. When the negatives of these images were viewed, there were too many grey-scaled images in the background that distracted the reader from the foreground. It was therefore decided to test the printed version first.

## NEWTON'S FIRST LAW

The concept of inertia is embodied in Newton's First Law of Motion.

*A body will remain at rest or continue with uniform velocity in a straight line, unless it is acted upon by an external resultant force.*

The mass of an object serves as a quantitative measure of its inertia.

3

### Questions

1. What is inertia?
2. Formulate Newton's First Law.
3. How can inertia be measured quantitatively?
4. Is Newton's First law only applicable to objects at rest?

## NEWTON'S SECOND LAW

Newton's First Law tells us that we need a resultant force to change an object's state of motion.

Newton's Second Law addresses the issue of how a resultant force will affect the object's motion.

1

## NEWTON'S SECOND LAW

To investigate the effect of a resultant force on a mass, the following needs to be done:

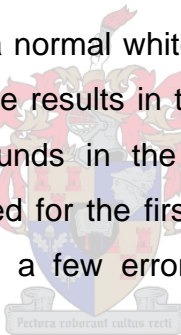
1. Investigate the effect of a constant force on a constant mass.
2. Investigate the effect of changing the force on a constant mass.
3. Investigating the effect of changing the mass while the force is kept constant.

2

As was expected, the printed version required too much toner. Although the originals were very clear, the copied versions often resulted in text that was illegible. During the testing of the CAIR in my classroom during the Prototyping Stage, other problems arose concerning the background.

Although I had used a similar setup of a television connected to a PC before, a new television and PC were now being used. The new equipment (probably the new video card in the PC) illuminated the background too much. It did not appear the same as on the PC monitor at all. It was much too prominent and distracted the viewer from the foreground. Many different settings on both the PC and the television were tested, but a satisfactory setting could not be found. If this were a problem for me, who has experience in using such systems, inexperienced teachers would most likely struggle to obtain acceptable results. It was decided that a solution had to be found that would address both the printing problem and the problems relating to the image on the television screen.

One could reason that black text on a normal white background could solve the problem, but one has to bear in mind that white results in too much flickering on the television. I decided to change all the backgrounds in the original slides to plain black. The background images were only retained for the first navigation slide of the slide show. I also used the opportunity to correct a few errors that were found during use in the classroom.



All the slide shows then had to be recompiled and the images had to be recaptured for printing. The process now involved an extra step. After the images had been captured, they were grey-scaled and then they were converted into a negative image. This meant that the black background became white and the white text became black. This resulted in much better images for both the printed version and the television screen.

The following page is an example of the new printed version.



## NEWTON'S FIRST LAW

The concept of inertia is embodied in Newton's First Law of Motion.

*A body will remain at rest or continue with uniform velocity in a straight line, unless it is acted upon by an external resultant force.*

The mass of an object serves as a quantitative measure of its inertia.

3

### Questions

5. What is inertia?
6. Formulate Newton's First Law.
7. How can inertia be measured quantitatively?
8. Is Newton's First law only applicable to objects at rest?

## NEWTON'S SECOND LAW

Newton's First Law tells us that we need a resultant force to change an object's state of motion.

Newton's Second Law addresses the issue of how a resultant force will affect the object's motion.

1

## NEWTON'S SECOND LAW

To investigate the effect of a resultant force on a mass, the following needs to be done:

1. Investigate the effect of a constant resultant force on a constant mass.
2. Investigate the effect of changing the resultant force on a constant mass.
3. Investigating the effect of changing the mass while the resultant force is kept constant.

2

## **4.8 The mechanics of the training process**

Reporting the training process is important for three reasons:

1. Training forms an integral part of the developmental process;
2. The training process was assessed by the teachers. These responses need to be assessed against the reported process;
3. It is important to establish how much time would be needed for training, as teachers would need to be absent from school to receive training. This will be an important consideration for educational authorities when considering this solution for implementation.

Eight schools in the Western Cape were chosen to participate in the project. They were all TRAC schools, meaning each school already had a TRAC system and a PC available to them. It also meant that the teachers had some exposure to using computers in the classroom. As the TRAC system was used to facilitate practical investigation only, teachers had to be introduced to the concept of using computers as a teaching resource. This meant that they had to be put through a training process to introduce them to the concept as well as the specifics of using the CAIR.

The specifics of what was covered during the training programme are described in the Addendum called "Training material". It should be noted that the CAIR was designed with the idea that teachers would be able to master it with the minimum of training. To make this process cost- and time-effective, the aim was to do the training in one day and to give the teachers the opportunity to experience the use of the CAIR first hand by doing a short presentation on that day.

## **4.9 The training programme**

### **4.9.1 Technical background**

During this session of the programme, teachers were introduced to the idea of using presentation-type software. This was divided into two sub-sessions. The first presented teachers with the hardware that is needed to project the images. They were introduced to both data projectors (as used during the training session) and to using televisions, connected, via a PC-to-TV card, to a personal computer (as they would use in their classrooms).



The second session introduced them to two different types of software, the first being programs such as PowerPoint (Microsoft), Presentations (Corel) or Impression (Sun), and the second being web-ready presentations such as the CAIR they would be using. They were also introduced to examples of how video and animations are used in presentation software.

#### **4.9.2 File management**

I have often found that computer users are unaware of how to organise files and execute programs. Although the CAIR would be installed on the computers for the teachers and would appear on both the start menu and desktop as a shortcut for the teachers, it was felt that teachers should be able to access the CAIR if anything went wrong with either the start menu or the desktop. I also wanted to make sure that teachers understood the basic principles behind creating folders and managing files, as this could help to overcome any fear that they may have of “messing things up” or “accidentally erasing files”. They were given CDs with copies of the CAIR should they need to reinstall it on their computers.

It was also hoped that a firm understanding of file management could possibly minimise the need for technical support when teachers started using the CAIR in the classroom.

#### **4.9.3 Using the CAIR**

Teachers also had to be introduced specifically to the use of the CAIR. This meant explaining to them how to access the executable files on their computers as well as how to navigate through the CAIR.

The idea that the next piece of information would be presented by the next click had to be demonstrated. Although the CAIR was designed so that they could theoretically click anywhere on the screen, clicking would have no effect if the mouse pointer were placed on a flash animation. This also had to be demonstrated so that teachers would be able to troubleshoot the non-responsiveness of the program in certain cases. As this was the only exception to the “clicking rule”, and it was hoped that it would not pose too big a problem.

The controlling of animations and the use of right click to replay, rewind or forward animations also had to be illustrated. I had found that I had to use this function many times in my own lectures during the Prototyping Stage.

The specific use of the first slide in every presentation needed special mentioning as this holds the key to starting the next day's lesson at the point where the teacher left off on the previous day.

#### **4.9.4 The practice session**

Teachers were given an opportunity to practice using the CAIR on their own in preparation for a presentation. The computers in the TRAC laboratory were used for this purpose and I aided teachers if they had any difficulties.

They were also encouraged to develop a feel for using the projected image (by means of the data projector) during this session.

#### **4.9.5 Teacher presentations**

Teachers were given an opportunity to do a presentation.

The motivation for this was to give teachers an opportunity to develop a feel for using the CAIR in front of an audience. I also used the opportunity to evaluate the process by using the measuring instrument for the Training Stage (see Addenda).

#### **4.9.6 Evaluation by teachers**

Teachers were required to complete the teacher evaluation questionnaires (see Addenda) for the Training Stage after they had done their presentations. These would be compared to the results of a similar questionnaire that they would complete after having used the CAIR during the Piloting Stage.

The results of the evaluation are presented in Chapter 5.

## Chapter 5

# INSTRUMENTS AND EMPIRICAL RESULTS OF THE EVALUATION PROCESS

## 5.1 Introduction

Evaluation instruments had to be designed for the Prototyping, Training and Piloting Stages of this study. These instruments had to be designed according to the following criteria that were reported in Chapter 2 (see p. 48). In designing these instruments the same criterion was often deliberately used more than once in different evaluation instruments and even more than once in the same evaluation instrument. This gave respondents the opportunity to evaluate a certain aspect from different angles. The number in brackets indicates how many times the specific criterion was used in the design of the evaluation instruments.

### Didactical Considerations:

1. relevance of software to the curriculum (2);
2. the effect on learner attitudes and edutainment value (enjoyment of the lesson) in keeping their attention (2);
3. contribution to teaching process in terms of structuring the lesson (5);
4. effectiveness as a timesaver for the teacher (2);
5. integration with TRAC system (7);
6. effectiveness of the notes (4);
7. correctness and comprehensiveness of content (2);
8. the amount of flexibility that the resource allows the teacher (1);
9. way in which the content is presented and uncovered to the learners (1).

### Visual Considerations:

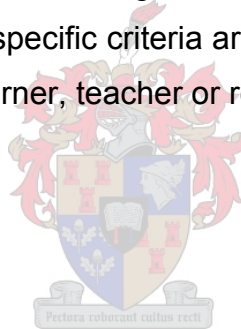
1. effectiveness of animations in visualisation of concepts (2);
2. contribution of graphics to attractiveness of information (2);
3. appeal of user interface (visual appeal of software)(2);

4. clarity of presentation (2).

### **Technical Considerations:**

1. cost effectiveness (1);
2. effectiveness of training (3);
3. time needed to become comfortable with the technology (2);
4. technical support required during use (1);
5. effectiveness of providing in-service training to teachers (1);
6. ease of use and ease of navigation within the CAIR (6).

What follows is an indication of how each criterion was used in the evaluation process to develop the content of the evaluation instruments. Each criterion is listed and, below that, the question (in a questionnaire) or category (in the researcher's rubric) that served that specific criterion. To avoid confusion, the criteria mentioned above will be referred to as general criteria, and the questions and categories in the evaluation instruments will be referred to as specific criteria. The specific criteria are coded with L, T or R, depending on whether they were for use by the learner, teacher or researcher.



## **5.2 Specific Criteria**

### **5.2.1 Didactical Considerations**

#### **1. Relevance of software to the curriculum (2)**

- a) Do you feel that you are being better prepared through the use of this method or not? Motivate your response. (L)
- b) Did you find the content to be correct, comprehensive and relevant to the curriculum? If not, please indicate the shortfalls. (T)

#### **2. The effect on learner attitudes and edutainment value (enjoyment of the lesson) in keeping their attention (2)**

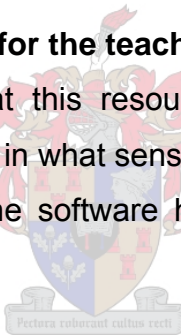
- a) Did you like or dislike the computer-based presentation method? Motivate your answer. (L)
- b) Did you find this method more entertaining than other teaching methods that you have encountered? Motivate your answer. (L)

### 3. Contribution to teaching process in terms of structuring the lesson (5)

- a) Do you think the lesson was more structured (better organised) than others that you have experienced before? Please say why it was, or why it was not. (L)
- b) Integration with other media: Is the teacher using the resource simply as a resource or does it become the only thing that the teacher does? Does the software therefore become too dominant in the delivery of new learning material? (R)
- c) Integration into the structure of the lesson: Is the resource something that the teacher uses before or after he/she has taught the lesson or does it form an integrated entity with the lesson? (R)
- d) Do you think this resource could help you in structuring your lesson? (T)
- e) Did the software help you to structure your lessons? (T)

### 4. Effectiveness as a timesaver for the teacher (2)

- a) Do you think that this resource could help save you time in the classroom? If so, in what sense? (T)
- b) Did the use of the software help save you time in the classroom? Why? (T)



### 5. Integration with TRAC system (7)

- a) Did the use of the TRAC system for practicals help you to better understand the concepts in those practicals? (L)
- b) Did you like or dislike the format of the practical sheets that you had to complete? If you choose dislike, please say how you would improve them. (L)
- c) Did you work in groups and did that make it harder for you to benefit from the practical? (L)
- d) What did you dislike about the TRAC system? (L)
- e) How did you integrate the use of this resource with the TRAC system? Did you do specific practicals directly after the theory or did you leave them till later? (T)
- f) Did your learners perform the practicals in groups, individually or did you do a demonstration? (T)

- g) What did you like and dislike about the TRAC system? (T)

**6. Effectiveness of the notes (4)**

- a) Did you find the notes easy or hard to study from? Please motivate your answer. (L)
- b) Did you use the blank pages next to the slides to take extra notes/examples off the board? (L)
- c) What, apart from the notes, did you use to study from in preparation for tests and exams? (L)
- d) Did you like the layout of three slides per page in the notes or would you have preferred it to be different? How would you have changed it? (L)

**7. Correctness and comprehensiveness of content (2)**

- a) Did you find the content to be correct, comprehensive and relevant to the curriculum? If not, please indicate the shortfalls. (T)
- b) Were there enough, too few or too many examples in the resource? (T)

**8. The amount of flexibility that the resource allows the teacher (1)**

- a) Did the resource allow for enough flexibility or did you feel restricted by it? Please motivate. (T)

**9. Way in which the content is presented and revealed to the learners (1)**

- a) Did you like or dislike the way in which content was revealed and presented to the learners? If you disliked it, how would you have wanted it to be different? (T)

**5.2.2 Visual Considerations**

**1. Effectiveness of animations in visualisation of concepts (2)**

- a) Did the use of animations (moving images) make it easier to understand some of the concepts that were being explained, or would the explanation have been just as effective without it? (Think of the moving arrows illustrating vector addition and animation of river problems showing the motion of the boat.) (L)

- b) Do you think that the animations were effective and that they helped learners to understand some concepts more easily? Please motivate. (T)

## 2. Contribution of graphics to attractiveness of information (2)

- a) Did the images (not the animations) make the presentation more attractive or did you find their use unnecessary? (L, T)

## 3. Appeal of user interface (visual appeal of software) (2)

- a) Did you like the use of the computer and television combination as a teaching resource more or less than other media that you have been exposed to (e.g. overhead transparencies, blackboard, textbook, etc)? Motivate your answer. (L)
- b) Does the software appeal to you visually? If not, what do you not like? (T)

## 4. Clarity of presentation (2)

- a) Could you easily see what was presented on the television? If not, state what made it difficult. (L)
- b) Did the learners struggle to see on the television? If they did, please state what the problem was. (T)

### 5.2.3 Technical Considerations

#### 1. Cost effectiveness (1)

- a) If you consider that you would need a PC and a TV to use this software in the classroom, would it be worth the cost to have it in your classroom? Please motivate your response. (T)

#### 2. Effectiveness of training (3)

- a) Confidence: The confidence with which the teacher uses the software could be an indication of the effectiveness of the training. (R)
- b) Do you feel adequately prepared by the training to use this resource in the classroom? If not, state why not and what else needed to be done in the training session. (T)



- c) Did the training prepare you adequately for use in the classroom? If not, please state why not. (T)

**3. Time needed to become comfortable with the technology (2)**

- a) Would you need much more time to become comfortable with the use of this resource? If so, why? (T)
- b) How long did it take for you to become comfortable with the use of the resource? What made it easy/hard? (T)

**4. Technical support required during use (1)**

- a) Did you need technical support at any stage of using the software? What was the problem and where did you obtain support to solve the problem? (T)

**5. Effectiveness of providing in-service training (1)**

- a) Did the software help to clear up any misconceptions that you had in Mechanics to the extent that it helped you to teach it more effectively? (T)

**6. Ease of use and ease of navigation within the CAIR (6)**

- a) Mouse skill: If teachers struggle with the use of the mouse, it could lead to them not wanting to use the PC as a resource. This is specifically monitored to compare it to the level of improvement during the Piloting Stage. (R)
- b) Understanding of navigational system: The teachers' use of the first page as well as their control of flash animations is of importance. (R)
- c) Mobility, eye contact, enthusiasm, interaction: Is the teacher so comfortable and at ease with the use of the PC that he/she is able to move away from it and not get stuck at the front of the classroom? Does the use of the equipment make the teacher interact with the equipment only and not with the class? Is there so much apprehension about the use of the equipment that the teacher projects no enthusiasm for the material at all? All of these indicate the ease of use by the teacher. (R)

- d) Do you find it easy or difficult to navigate through the slides? Please say what you like or dislike or what you struggle with. (T)
- e) Which aspect of using this resource do you find to be the most difficult or laborious? Please state why. If you have no problems with any aspect please also state that. (T)
- f) Please state if you had problems with each of the following or not, and also please specify the difficulty: (T)

Navigating through the slides;

Controlling the animations.

The instruments that were used for each of the three stages are reported under a separate heading for each stage.

### **5.3 Instruments for Prototyping Stage**

#### **5.3.1 Initial informal assessment of PowerPoint Presentations**

The Prototyping Stage had actually already started in June 1998 with the introduction of PowerPoint presentations in my classroom. The reason for investigating this method can be found in the particular situation that I was in. Three classes of Grade 11 learners had to be taught every day and the following year four classes of Grade 12 students needed to be taught every day. This presented some logistical problems in making sure that every class covered exactly the same material as every other class and that some things are not forgotten in some classes that were taught in previous ones. Although it is usually quite easy to keep track of things when only one class is being taught, things can become quite confusing when the same thing has to be taught four times. As different classes may have different needs, they would not all move at the same pace and one could easily forget to do a certain section with one class if one does not keep track of things properly.

One way of keeping track would, of course, be to simply make a note of where each class is on a specific day. Another way would be to design one's teaching resources in such a way that one keeps track of where one is by simply knowing up to which point one taught on a specific day. The latter method forces one to prepare properly and to develop a set of resources that could be improved every year. One could opt for overhead transparencies, writing a set of notes or using a combination of different resources. None of the available methods appealed to me, as they would entail major and costly

redevelopment of resources every time I wanted to improve or change something. I also wanted the notes that the learners receive to be the same as that which they would see in resources. This would save them time by not having to take down notes.

The development of PowerPoint presentations was therefore a trial run to investigate if the medium offered a better solution to some of the challenges that were being faced than some of the more conventional approaches did. Unfortunately I did not evaluate the system with the notion of presenting a formal study; however, a questionnaire was given to the learners at the end of each year to assess their reaction to the method that was being used. The responses were then used to improve and change the presentations where needed. The feedback from the learners at the end of 1998, 1999 and 2000 was very positive. It is not possible to present a detailed analysis of their responses, as they were not kept. They liked not having to take down notes and indicated that the presentations were more entertaining, thereby helping them to concentrate. In the two years there were only two negative comments, one at the end of 1999 and the other at the end of 2000. Neither of these comments was specifically about any particular aspect of the presentation. Some of the learners had much more constructive criticism and asked for more multimedia content like video clips. A number of them said that they wanted more examples in the notes.

These comments led to an investigation into animation and an increase in the number of worked-out examples. One could increase the number of examples even further, but I felt that it would be better to present the examples as problems that the students have to try and solve in class. They would then be guided to the solutions and presented with a full solution only after some effort on their part. I felt that students had to be actively involved in the problem-solving process and that one had to be careful about succumbing to their wanting to be spoon-fed. The notes were therefore printed in such a way that there were blank pages next to the printed slides on which the students could do extra examples.

These comments from students led to a PowerPoint version for the Grade 11 and Grade 12 syllabi and a book with the slides printed in them. It was only after I became aware of the involvement of the Department of Didactics in the Faculty of Education at the University of Stellenbosch in the TRAC programme that an interest developed to formalise this research. Although the process had been informally evaluated three times for the PowerPoint version, the first properly designed evaluation instrument was used for the

web-ready version of Mechanics that was taught in 2001 in the Prototyping Stage of the newly developed software.

### 5.3.2 Formal assessment of web-ready software

The new evaluation involved a questionnaire that was to be answered by the learners after their formal June examination. They had then experienced the whole package and had been using the notes for six months. They were also able to reflect on their use of the notes during their preparation for exams.

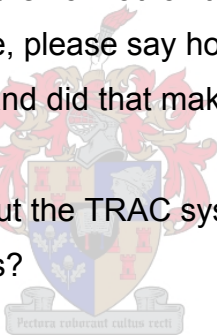
The questionnaire was designed with the didactical, visual and technical considerations in mind. The questions are coded as follows: D1, V1 and T1 refer to the first criterion under didactical, visual and technical considerations respectively. During the Prototyping Stage, a number of typing errors that were discovered by students and me were corrected.

Learners were asked to motivate most of their answers as this opened up an opportunity for them to communicate problems or certain aspects that were not being asked for directly. The following section shows which specific criteria were addressed in the Prototyping Stage learner questionnaire.

#### Prototyping Stage learner questionnaire

1. **D2:** Did you like or dislike the computer based presentation method? Motivate your answer.
2. **V3:** Did you like the use of the computer and television combination as a teaching resource more or less than other media that you have been exposed to (e.g. overhead transparencies, blackboard, textbook, etc)? Motivate your answer.
3. **V4:** Could you easily see what was presented on the television? If not, state what made it difficult.
4. **V1:** Did the use of animations (moving images) make it easier to understand some of the concepts that were being explained, or would the explanation have been just as effective without it? (Think of the moving arrows illustrating vector addition and animation of river problems showing the motion of the boat.)
5. **D2:** Did you find this method more entertaining than other teaching methods that you have encountered? Motivate your answer.
6. **V2:** Did the images (not the animations) make the presentation more attractive or did you find their use unnecessary?

7. **D3:** Do you think the lesson was more structured (better organised) than others that you have experienced before? Please say why it was, or why it was not.
8. **D6:** Did you find the notes easy or hard to study from? Please motivate your answer.
9. **D6:** Did you use the blank pages next to the slides to take extra notes/examples off the board?
10. **D6:** What, apart from the notes, did you use to study from in preparation for tests and exams?
11. **D6:** Did you like the layout of three slides per page in the notes or would you have preferred it to be different? How would you have changed it?
12. **D1:** Do you feel that you are being better prepared through the use of this method or not? Motivate your response.
13. **D5:** Did the use of the TRAC system for practicals help you to better understand the concepts in those practicals?
14. **D5:** Did you like or dislike the format of the practical sheets that you had to complete? If you choose dislike, please say how you would improve them.
15. **D5:** Did you work in groups and did that make it harder for you to benefit from the practical?
16. **D5:** What did you dislike about the TRAC system?
17. **General:** Any other remarks?



The evaluation criteria that have not been covered by this instrument are the following:

**D4:** effectiveness as a timesaver for the teacher;

**T1 – T6:** all of the technical criteria.

These criteria are obviously directed more to the teacher than to the student as the student would have very little, if any, insight into these matters. These criteria enjoyed much more attention in the Training and Piloting Stages.

## 5.4 Instruments for Training Stage

The evaluation during this stage had to be done by two separate parties. The first party is the researcher. The Training Stage lent itself to an opportunity to assess the attitudes and abilities of the teachers who would use the software. Many of the technical criteria could therefore enjoy some attention and consideration during this stage. The second party was

the teachers. The instruments used by these parties will be discussed in the next two sections.

#### 5.4.1 Instrument for use by the researcher

This instrument is one that I used during interviews and observation of teachers during the Training Stage. During the training each of the teachers was given an opportunity to present a few slides in the Mechanics topic of their choice. The result of an evaluation during this process could then be compared to the evaluation that would be done during the Piloting Stage. I also made field notes while observing teachers, if I noticed things that were not specifically mentioned in the rubric.

	1	2	3	4	5
<b>Confidence</b>					
<b>Mouse skill</b>					
<b>Understanding of navigational system</b>					
<b>Integration with other media</b>					
<b>Integration into the structure of the lesson</b>					
<b>Mobility</b>					
<b>Eye contact</b>					
<b>Enthusiasm</b>					
<b>Interaction</b>					

**Figure 7: Instrument used by researcher**

The categories in this rubric were specifically chosen to address some of the possible pitfalls when using media. The London School of Economics and Political Science website for Teaching and Learning (2001) lists a number of criteria for assessing teachers in seven categories. Some of these are enthusiasm, confidence, warmth and creativity as reflected under their personal communications skills heading. Some of these have also been incorporated into this rubric.

This rubric was used again in the classroom to evaluate the teachers. Results were then compared to identify areas with which teachers had difficulty. The next section gives a brief description of each category and shows which specific criteria were addressed in this instrument. One indicates a low rating and five a high rating.

- **T2:** Confidence: The confidence with which the teacher uses the software could be an indication of the effectiveness of the training.
- **T6:** Mouse skill: If teachers struggle with the use of the mouse, it could lead to their not wanting to use the PC as a resource. This is specifically monitored to compare it to the level of improvement during the Piloting Stage.
- **T6:** Understanding of navigational system: The teachers' use of the first page as well as their control of flash animations is of importance.
- **D3:** Integration with other media: Is the teacher using the resource simply as a resource or does it become the only thing that the teacher does? Does the software therefore become too dominant in the delivery of new learning material?
- **D3:** Integration into the structure of the lesson: Is the resource something that the teacher uses before or after he/she has taught the lesson, or does it form an integrated entity with the lesson?
- **T6:** Mobility, eye contact, enthusiasm, interaction: Is the teacher so comfortable and at ease with the use of the PC that he/she is able to move away from it and not get stuck at the front of the classroom? Does the use of the equipment make the teacher interact with the equipment only and not with the class? Is there so much apprehension about the use of the equipment that the teacher projects no enthusiasm for the material at all? All of these indicate the ease of use by the teacher.

#### **5.4.2 Instrument for use by trained teachers**

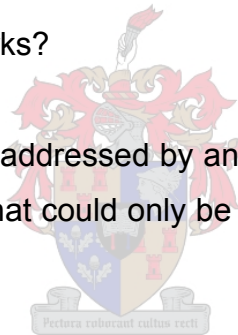
In the effort to evaluate the Training Stage properly, it was also necessary to obtain feedback from the teachers. This feedback was needed to assess the teachers' experience and attitudes towards the use of the CAIR. The next section shows which specific criteria were addressed in this instrument. The evaluation instrument was once again a questionnaire in which teachers were required to motivate their response.



### Training Stage teacher questionnaire

1. **T2:** Do you feel adequately prepared by the training to use this resource in the classroom? If not, state why not and what else needed to be done in the training session.
2. **D4:** Do you think that this resource could help save you time in the classroom? If so, in what sense?
3. **D3:** Do you think this resource could help you in structuring your lessons?
4. **T3:** Would you need much more time to become comfortable with the use of this resource? If so, why?
5. **T6:** Do you find it easy or difficult to navigate through the slides. Please say what you like or dislike or struggle with.
6. **V3:** Does the software appeal to you visually? If not, what do you not like?
7. **T6:** Which aspect of using this resource do you find to be the most difficult or laborious? Please state why. If you have no problems with any aspect, please also state that.
8. **General:** Any other remarks?

The only criteria that have not been addressed by any of these evaluation instruments are T1, T4 and T5. These are issues that could only be tested after the teacher has used the system for a while.



## 5.5 Instruments for Piloting Stage

The evaluation for the Piloting Stage had to be done by all parties involved, namely learners, teachers and researcher.

### 5.5.1 Instrument for use by the learners

The same instrument that was used during the Prototyping Stage (see p. 97) was used here again. This instrument could only be used after the teacher has completed the use of the software and done the TRAC experiments. As the aim of the study was to determine how the CAIR was received by all the parties involved, the perception of learners that are exposed to the CAIR is vital in evaluating the success of the resource.

The evaluation was aimed at exposing issues surrounding teacher presentation, appeal of the interface and effectiveness as a learning resource. It has to be remembered that, even if the CAIR does help the teachers to structure their lessons, it will not be effective as a

resource if the learners don't like it and find it difficult to study using the notes. To determine if the CAIR is failing owing to presentation problems by the teacher or owing to personal likes or dislikes of the learners, it is necessary to consider learners' motivations for their answers. These issues are equally important in improving the CAIR.

### 5.5.2 Instrument for use by the teachers

Teachers asked learners to complete a questionnaire after having implemented the CAIR in the Piloting Stage. The responses to these questions had to be compared to the responses in the Training Stage questionnaire. The next section shows which specific criteria were addressed in this instrument.

#### Piloting Stage teacher questionnaire

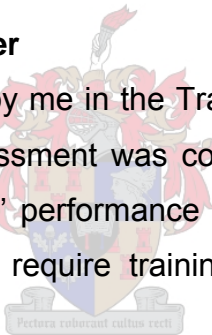
1. **T2:** Did the training prepare you adequately for use in the classroom? If not, please state why not.
2. **T5:** Did the software help to clear up any misconceptions that you had in Mechanics to the extent that it helped you to teach it more effectively?
3. **D4:** Did the use of the software help save you time in the classroom? If so, why?
4. **D3:** Did the software help you to structure your lessons?
5. **T3:** How long did it take you to become comfortable with the use of the resource? What made it easy/difficult?
6. **T6:** Please state if you had problems with each of the following or not, and also please specify the difficulty:
 

Navigating through the slides;  
 Controlling the animations.
7. **T4:** Did you need technical support at any stage of using the software? What was the problem and where did you obtain support to solve the problem?
8. **T1:** If you consider that you would need a PC and a TV to use this software in the classroom, would it be worth the cost to have them in your classroom? Please motivate your response.
9. **D1, D7:** Did you find the content to be correct, comprehensive and relevant to the curriculum? If not, please indicate the shortfalls.
10. **D7:** Were there enough, too few or too many examples in the resource?
11. **D8:** Did the resource allow for enough flexibility or did you feel restricted by it? Please motivate.

12. **D9:** Did you like or dislike the way in which content was revealed and presented to the learners? If you disliked it, how would you have wanted it to be different?
13. **V1:** Do you think that the animations were effective and that they helped learners to understand some concepts more easily? Please motivate.
14. **V2:** Did the images (not the animations) make the information more appealing or were they unnecessary?
15. **V4:** Did the learners struggle to see on the television? If they did, please state what the problem was.
16. **D5:** How did you integrate the use of this resource with the TRAC system? Did you do specific practicals directly after the theory or did you leave them till later?
17. **D5:** Did your learners perform the practicals in groups, individually or did you do a demonstration?
18. **D5:** What did you like and dislike about the TRAC system?
19. **General:** Any other remarks?

### 5.5.3 Instrument used by researcher

The same instrument that was used by me in the Training Stage was used in the Piloting Stage again. The result of the assessment was compared to the result of the Training Stage to determine how the teachers' performance changed over time. This could also give an indication of which aspects require training and which require experience to develop.



## 5.6 Results of the evaluation process for the Prototyping Stage

The reason for the Prototyping Stage evaluation was to determine the aspects of the CAIR that did not work and that could be corrected before going into a more rigorous testing in the Piloting Stage. This approach was consistent with the Rapid Prototyping method that was reported in Chapter 2 (see p. 38).

The following section gives a summary of the results obtained from the Prototyping Stage evaluation. At this stage it is necessary to explain how these statistics were obtained.

Data received from respondents were analysed on a spreadsheet. Each learner was given a numerical code. All questions were then analysed by labelling responses either as positive, negative or neutral. Motivations to responses were recorded under separate columns. This made it possible to keep track of how many times a specific response came

up either for a particular question or in total for all learners and all questions. The spreadsheet analysis also made it possible to set filters that would make it possible to determine, for instance, how many learners gave negative responses to a particular question. For the Piloting Stage spreadsheets were set up for each individual school with a summary sheet that could be used to obtain statistics for all schools in total.

### 5.6.1 Summary of results

Fifteen learners answered questions in the Prototyping Stage. A breakdown of the 218 responses given by the learners is shown in Table 3.

% Positive Response	% Negative Response	% Neutral Response
78.9	18.3	2.8

**Table 3: Breakdown of responses for Prototyping Stage**

The following table gives the questions to which negative responses were received. The frequency of negative responses is given in the column labelled  $f_{NR}$ . Any motivations for negative responses are given after the question with the frequency of those motivations under the column labelled  $f_{NM}$ . Frequencies for motivations did not always correspond with frequencies of negative responses. There are two reasons for this. The first is that some learners did not motivate answers and the second is that some gave a positive response, but chose to point out some things that were not liked. All motivations that are negative are listed next to questions below, regardless of whether they came from a positive or negative response.

		$f_{NR}$	$f_{NM}$
<b>Question</b>	1 D2): Did you like or dislike the computer based presentation method? Motivate your answer.	3	
<b>Negative motivation</b>	It is hard to understand		2
<b>Question</b>	2 (V3): Did you like the use of the computer and television combination as a teaching resource more or less than other media that you have been exposed to (e.g.	2	

		$f_{NR}$	$f_{NM}$
	overhead transparencies, blackboard, textbook, etc)? Motivate your answer.		
<b>Negative motivation</b>	Prefer to make own notes in class		1
<b>Question</b>	3 (V4): Could you easily see what was presented on the television? If not, state what made it difficult.	2	
<b>Negative motivation</b>	Want a bigger TV / projector in class		2
<b>Question</b>	5 (D2): Did you find this method more entertaining than other teaching methods that you have encountered? Motivate your answer.	1	
<b>Question</b>	6 (V2): Did the images (not the animations) make the presentation more attractive or did you find the use of them unnecessary?	3	
<b>Negative motivation</b>	Did not like black background		1
<b>Question</b>	7 (D3): Do you think the lesson was more structured (better organised) than others that you have experienced before? Please say why it was or why it was not.	2	
<b>Question</b>	8 (D6): Did you find the notes easy or difficult to study from? Please motivate your answer.	3	
<b>Negative motivations</b>	Black background made it hard		2
	Hard to understand		3
	Notes are impersonal		1
	Want important things to stand out		1
<b>Question</b>	9 (D6): Did you use the blank pages next to the slides to take extra notes/examples off the board?	1	
<b>Question</b>	11 (D6): Did you like the layout of three slides per page in the notes or would you have preferred it to be different? How would you have changed it?	3	

		$f_{NR}$	$f_{NM}$
<b>Negative motivations</b>	Want slides bigger		2
	Want full typed pages with examples		1
<b>Question</b>	12 (D1): Do you feel that you are being prepared better through the use of this method or not? Motivate your response.	7	
<b>Question</b>	14 (D5): Did you like or dislike the format of the practical sheets that you had to complete? If you choose dislike, please say how you would improve it.	1	
<b>Negative motivation</b>	Hard to understand		1
<b>Question</b>	15 (D5): Did you work in groups and did that make it harder for you to gain benefit from the practical?	3	
<b>Negative motivation</b>	Harder to work in groups		3
<b>Question</b>	16 (D5): What did you dislike about the TRAC system?	5	
<b>Negative motivations</b>	It is finicky		2
	Friction causes problems		2
	Too computer orientated		1

**Table 4: Frequencies for negative responses and negative motivations for the Prototyping Stage Learner Questionnaire**

Questions that received no negative responses were questions 4, 10 and 13. Question 10 is not really relevant to the analysis above as it asks learners what else they studied from and therefore does not necessarily require a positive or negative response.

The positive response to question 4 means that animations were liked by all and that they thought animations made concepts easier to understand. Question 13 tests if learners thought that the TRAC system helped them to understand concepts. The positive response here means that the learners thought that practicals played an important role in understanding. Positive motivations received from these learners are listed below.

Positive motivations	Frequency
It was interesting/different/fun	9
It was easier to understand	7
It was aesthetically better	8
It was easy to follow – knew where it was going	6
Liked the multimedia learning/animations	2
Did not need to make own notes in class/saved time	4
Better organised	1
Helps to discuss in groups	7
It is easier to learn from images	3
Studied from notes only	1
Disliked nothing in the TRAC system	8

**Table 5: Frequencies for positive responses to question 13 of the Prototyping Stage Learner Questionnaire**

Question 17 asked learners for any other remarks. This produced more negative motivations that were not listed above. To give the total picture for negative motivations, all of them are listed below.

Negative motivations	Frequency
Black background made it hard	5
Want slides bigger	4
Harder to work in groups	3
TRAC is finicky	2
More examples wanted	1
Hard to understand	8
Notes are impersonal	2
Friction in TRAC system causes problems	2
Prefer to make own notes in class	1
Want to do all the experiments	1



Negative motivations	Frequency
Want important things to stand out in notes	2
Would like audio as well	2
Want full typed pages with examples	1
Too computer orientated	1
Want a projector	2

**Table 6: Frequencies for all negative motivations to the Prototyping Stage Learner Questionnaire**

The results given above have been presented without discussion. In Chapter 6 these results are discussed to report on how the software was changed before the Piloting Stage.

## 5.7 Results of the evaluation process for the Training and Piloting Stages

The interpretation of questionnaires, classroom visits and interviews produced two types of data. Each response was labelled as positive, negative or neutral. This produced a set of quantitative data that provided a picture of how well the CAIR and the TRAC system were received. This set of data also lent itself to statistical analyses. For this set of data frequency responses were determined and chi-square tests were performed to compare responses between gender groups, socio-economic groups and different mother-tongues.

In their description of qualitative data analysis Bogdan and Biklen (cited in Hoepfl 1997: 7) refer to *...breaking it into manageable units* and *...searching for patterns*. Hoepfl (*ibid.*) talks about placing raw data *...into logical meaningful categories*. From the eight pilot schools that were chosen, 276 learners completed questionnaires. Learners did not always motivate their responses, even though they were requested to do so. In the search for patterns and meaningful categories, the data from these motivations were captured onto a spreadsheet. Motivations were recorded in separate columns on the spreadsheet so that the frequency of any motivation could be determined. This produced a second set of qualitative data that provided a picture of why responses were positive or negative.

Some negative responses did not necessarily mean that a specific feature was not liked. Sometimes it meant that the feature was not used. Question 9 on the learner questionnaire is a case in point, where many learners simply did not use the blank pages. Question 12 was also responded to negatively as many students felt that they had a good teacher and that the software did not improve their preparation. Although they would therefore answer negatively to this specific question, the understanding is that it does not necessarily mean that the CAIR is inadequate. Question 7 could have a negative response for the same reason. The reasons were not always easy to establish, as learners would not always motivate their responses. Where needed, these issues were addressed in follow-up learner interviews in an attempt to clear up uncertainties.

Because the CAIR is evaluated by means of a set of predetermined criteria, it makes sense to report the data produced by the study by referring to the relevant criterion in each case. Instead of reporting the results of statistical analyses of quantitative data and patterns and categories discovered in the qualitative analysis separately, these are rather reported together under the relevant criteria headings.

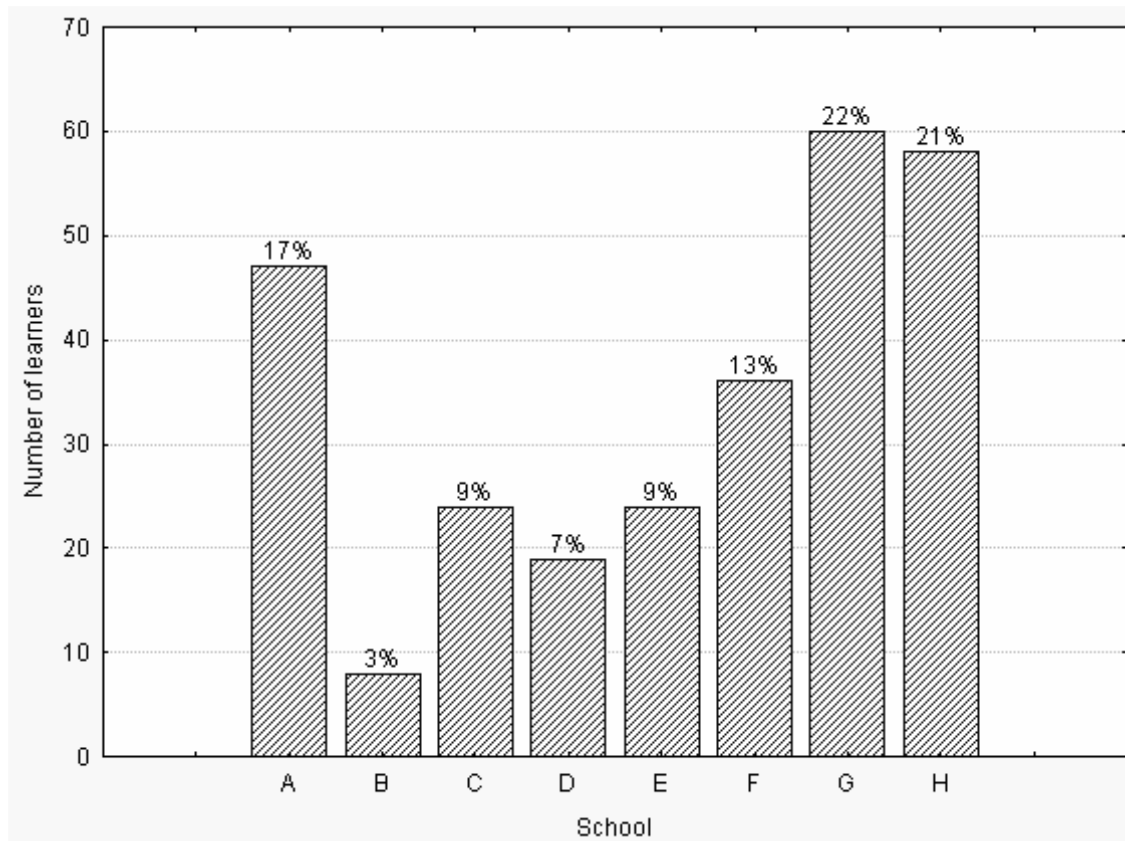
The following section reports on the demographical data of the learner sample in the piloting stage. This is done to show that the study attempted to (within the limitations of having to choose TRAC schools) follow the approach of maximum variation sampling as described by Lincoln and Guba (cited in Hoepfl 1997: 5) (see p. 43).

### **5.7.1 Demographic data of learners in the piloting stage**

The demographic data of learners in the piloting stage are summarised in the histograms that follow. The histograms represent demographic data for the 276 learners in six categories and show how learners are distributed between:

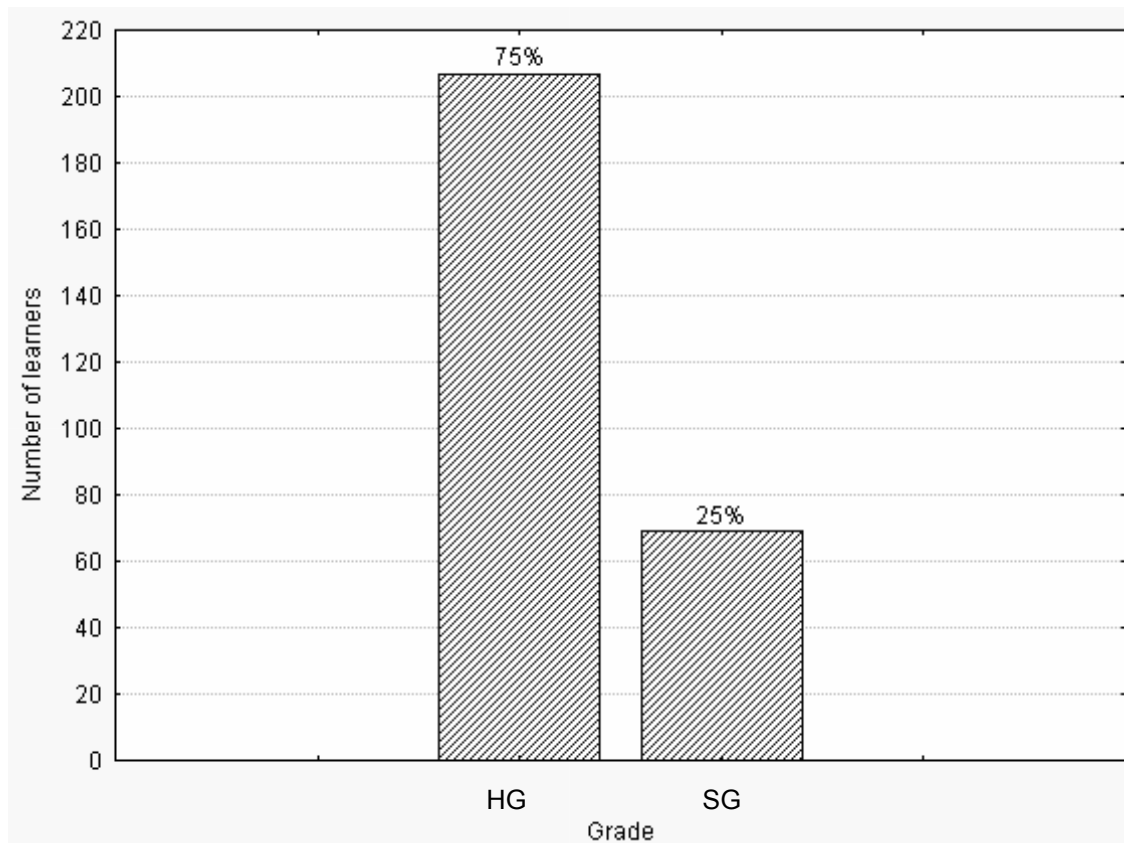
- schools;
- grade (the level on which the subject is taken is either Higher Grade or Standard Grade);
- performance in the previous formal exam that was written;
- socio-economic groups;
- gender groups;
- language groups.

The first histogram shows the distribution of learners between the eight Piloting Stage schools.



**Figure 8: Histogram of learner distribution between schools**

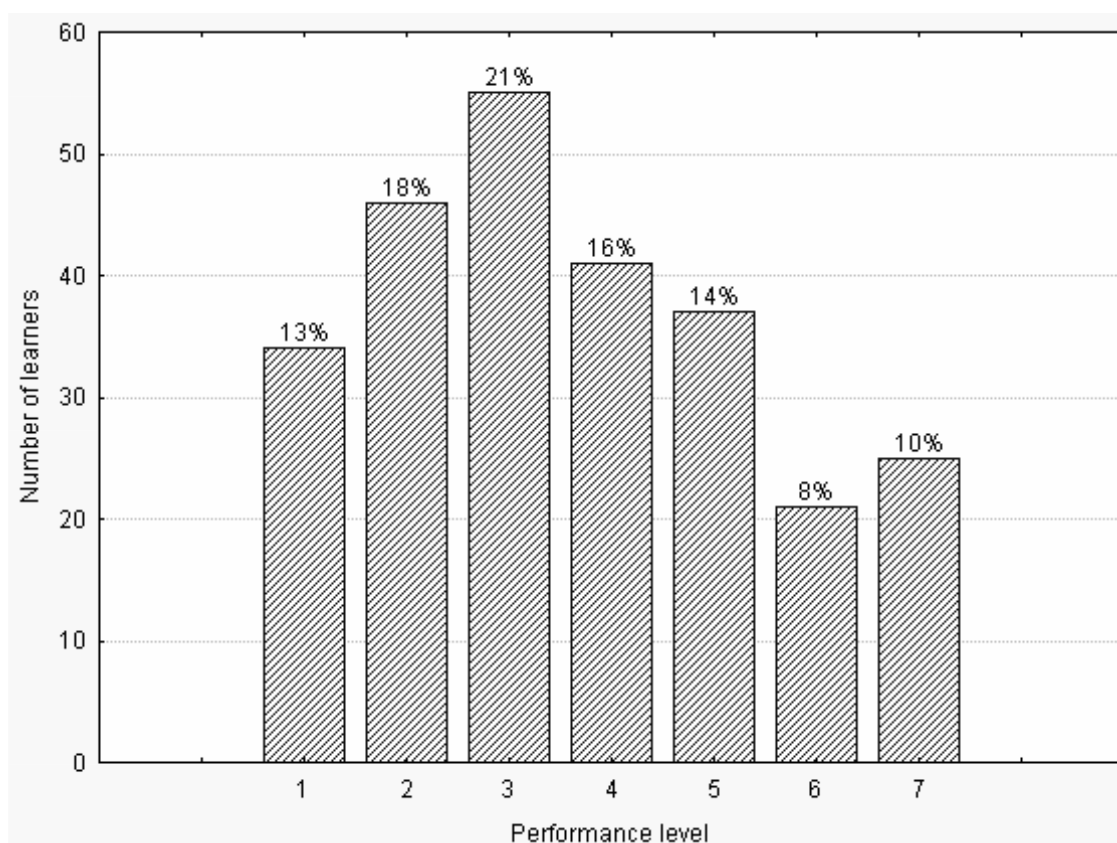
Physical Science can be followed on either the Standard or the Higher Grade. Higher Grade is indicated with HG in Figure 9 and Standard Grade is indicated with SG.



**Figure 9: Histogram of learner distribution between grades**

Performance in the previous exam is indicated on seven levels. These levels are defined as follows in Figure 10:

- Level 1: 80% - 100%
- Level 2: 70% - 79%
- Level 3: 60% - 69%
- Level 4: 50% - 59%
- Level 5: 40% - 49%
- Level 6: below 40%
- Level 7: no exam written



**Figure 10: Histogram of learner performance distribution**

In the histogram presenting distribution between socio-economic groups the following labels are used. **Group 1** represents learners from schools that have the **greatest financial need**. This could be seen in facilities that were lacking and quite often school buildings were in need of maintenance or repair. Facilities for extramural activities such as sport were either absent or very basic. These learners were also subject to social problems such as violence and gangsterism. During my visit to one of these schools, the principal related how learners from the school were shot at on their way to school on that specific morning. **Schools A, B, C and E** fall into this category.

**Group 2** represents schools that do not have as great a need as the group 1 schools. These schools had laboratories and equipment and apparatus that could add value to the learning experience. School buildings were in better condition and schools were situated in areas that are associated with a **middle-income group**. **Schools D and H** fall into this category.

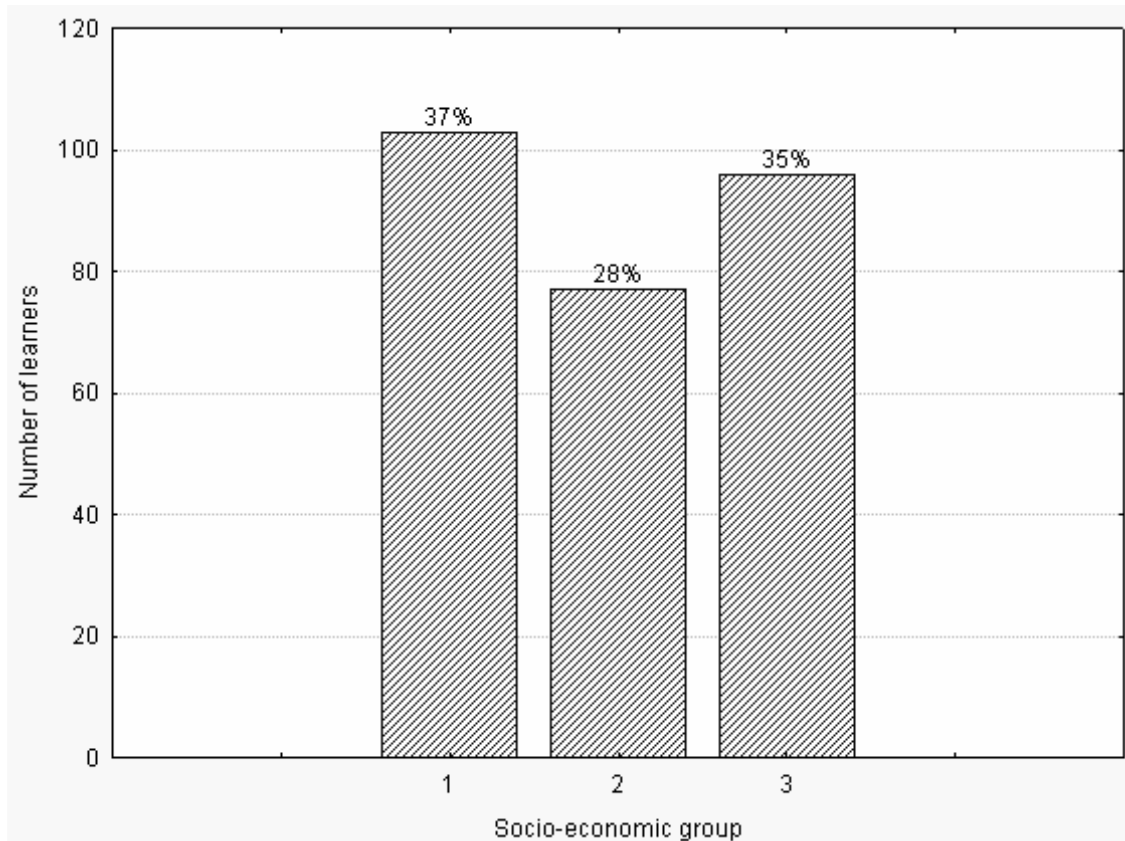
**Group 3** represented schools situated in **more affluent** areas. These schools were well-equipped and boasted excellent sports and other extramural facilities. **Schools F and G** fall into this category

The difference between the socio-economic groups also becomes evident if one compares the school fees paid per learner per year for each school. The following table gives a summary of this information.

School	Fee per learner per year for 2001 in Rand	Average fee per learner per year for 2001 for group in Rand
A	350	287.50
B	250	
C	300	
E	250	
D	2187	1843.50
H	1500	
F	4000	4600.00
G	5200	

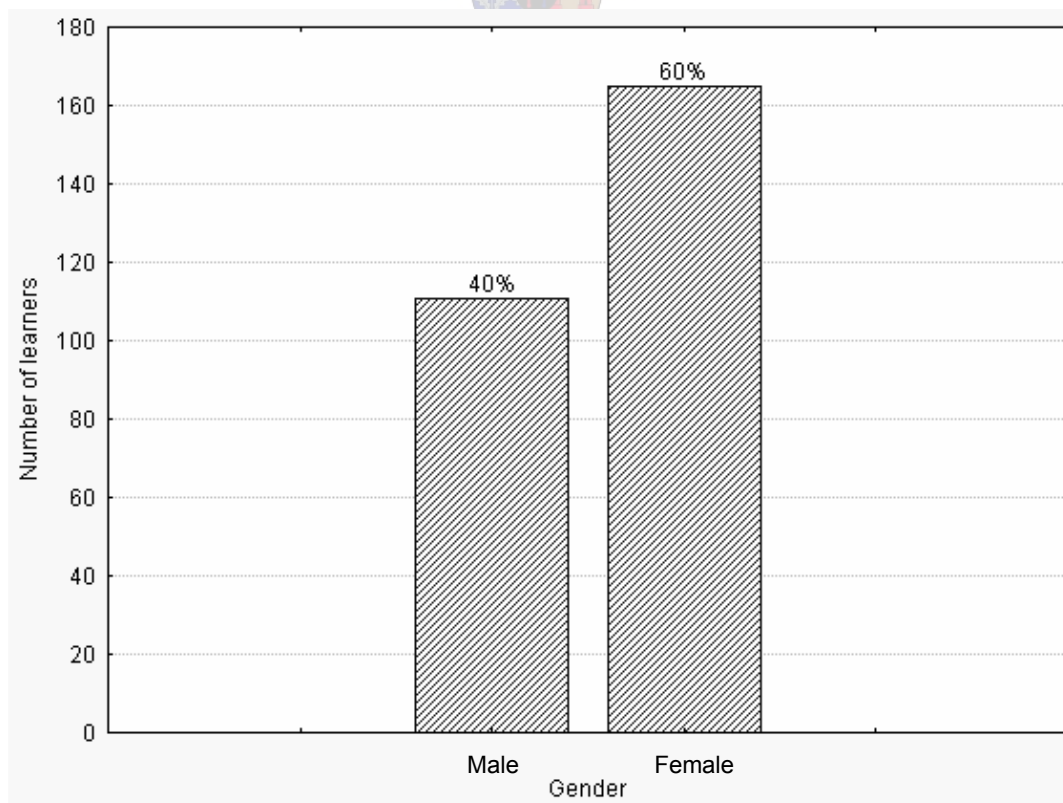
**Table 7: Breakdown of annual school fee per school and per socio-economic group**

The different groups are labelled with the numbers 1, 2 and 3 in Figure 11.



**Figure 11: Histogram of learner distribution between socio-economic groups**

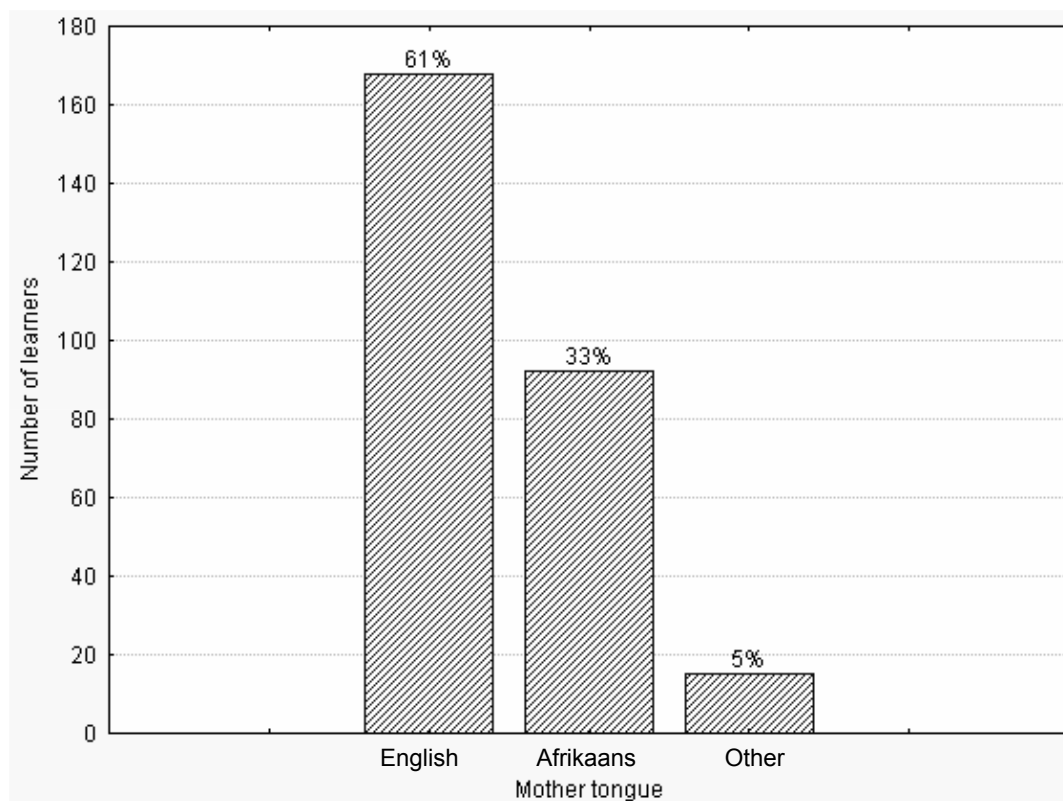
Figure 12 shows the gender distribution for learners from the piloting stage schools.



**Figure 12: Histogram of learner gender distribution**



Three language groups were identified. Figure 13 indicates the mother-tongue distribution between English, Afrikaans or other language. This was of particular interest as the CAIR was only available in English.



**Figure 13: Histogram of learner distribution between language groups**

## 5.7.2 Results of analyses of quantitative data for all criteria

### 5.7.2.1 Analysis for the whole group

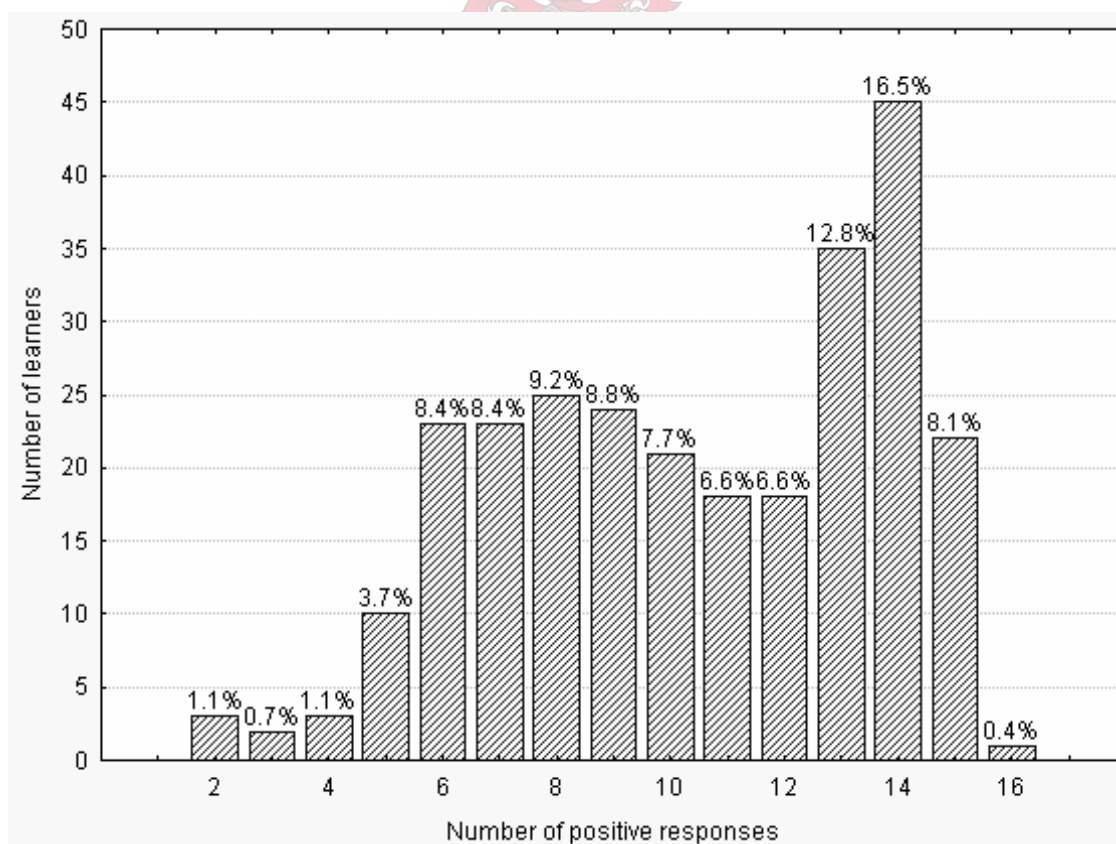
The following table gives us an idea of the total responses for all criteria from all eight schools. This analysis attempts to represent an overall picture of how the CAIR was received. The n-value represents the number of responses received in each school and not the number of respondents.

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 697)	91.2	8.0	0.7
B (n = 78)	85.9	11.5	2.6
C (n = 136)	86.8	13.2	0.0
D (n = 168)	95.8	2.4	1.8
E (n = 347)	92.8	6.9	0.3

School	% Positive Response	% Negative Response	% Neutral Response
F (n = 489)	76.5	20.9	2.7
G (n = 599)	74.3	19.7	6.0
H (n = 787)	93.1	6.0	0.9
All (n = 3301)	86.5	11.5	2.0

**Table 8: Breakdown of total learner responses for the whole group (All) and also for each individual school (A to H)**

Figure 14 gives a breakdown of how the positive responses were distributed amongst the questions. Learners could have given a positive response 16 times in the questionnaire since 16 of the 17 questions required either a positive, negative or neutral response. The 16,5% above the number 14 on the horizontal axis for example, indicates the 16,5% of learners answered positively to 14 of the 16 responses.



**Figure 14: Histogram of number of times learners responded positively**

Figure 14 speaks for itself; it is, however, interesting to note that if one adds the percentages above columns 8 to 16, one finds that 76,7% of learners responded positively to 50% or more (eight or more positive responses per learner) of the questions. To see the cumulative effect of positive responses, one needs to look at Table 8.

Table 8 indicates that 11,5% of all responses were negative. The 11,5% represents 378 negative responses. As this study is concerned with trying to improve on negative issues, a clearer picture needs to be obtained of the nature and significance of these negative responses with respect to the developmental process. Some issues will need clarification. If one, for instance, considers responses for questions 7, 9 or 12 by looking at the breakdown of responses in the tables given later in this chapter, one finds that 137 of the 378 negative responses mentioned above come from these three questions. It has already been mentioned (see p. 109) that the significance of negative responses in these questions would need to be clarified by interviews. Each question was analysed under the specific criteria given in section 5.2. This presents a clearer picture of how the CAIR performed during the Piloting Stage in each criterion. It also makes it possible to see feedback for each of the didactical, visual and technical considerations. The table above does, however, show an overwhelmingly positive response of 86,5%.

A cross-tabulation was done between schools to analyse the distribution of positive responses for all criteria. The chi-square test revealed significant differences between schools:  $X^2(98) = 308,9$ ;  $p = 0,00000$ . It was noticed that learners from school C had neglected to answer many questions (there were many blank responses), so the cross-tabulation was also done excluding school C. A chi-square test still revealed significant differences between the remaining schools:  $X^2(78) = 237,3$ ;  $p = 0,000000$ .

A comparison of actual frequencies revealed that responses from schools A (89,4% ( $n = 47$ ) of learners answered positively more than 11 times out of a possible 16), E (95,8% ( $n = 24$ ) of learners answered positively more than 11 times) and H (75,9% ( $n = 58$ ) of learners answered positively more than 11 times) were more positive than the expected frequencies of  $X^2$  test. (From this point on the phrase “than the expected frequencies of the  $X^2$  test” will be replaced by “than expected”). Responses from schools B (none of the learners answered positively more than 11 times), D (5% ( $n = 19$ ) of learners answered positively more than 11 times), F (30,5% ( $n = 36$ ) of learners, answered positively more than 11 times) and G (none of the learners answered positively more than 11 times) were

less positive than expected (The 11 times is not significant in any way. It is only used as a point of comparison here, as it was found that this was the point above which learners from schools B and G did not show any positive responses).

It is also interesting to note that schools F and G have a much higher percentage of negative responses than the other schools. Schools F and G serve more affluent socio-economic communities than the other schools. These students were therefore used to better facilities. Although it cannot be said that the teachers from these schools were necessarily better, it was clear that the students rated their teachers very highly. They would often reply that they were used to a good structure and being well prepared for exams. One was left with the impression that for them the CAIR was nice to have, but not a necessity. It would seem that these differences in response frequencies could be due to socio-economic factors. It should also be noted that school G is a girls-only school. This may lead one to believe that differences could be due to gender preferences. Another factor that could have played a role is language preference. As the reasons for differences in responses between schools are not easy to identify, the following sections focus on the analysis for different groups within the schools.

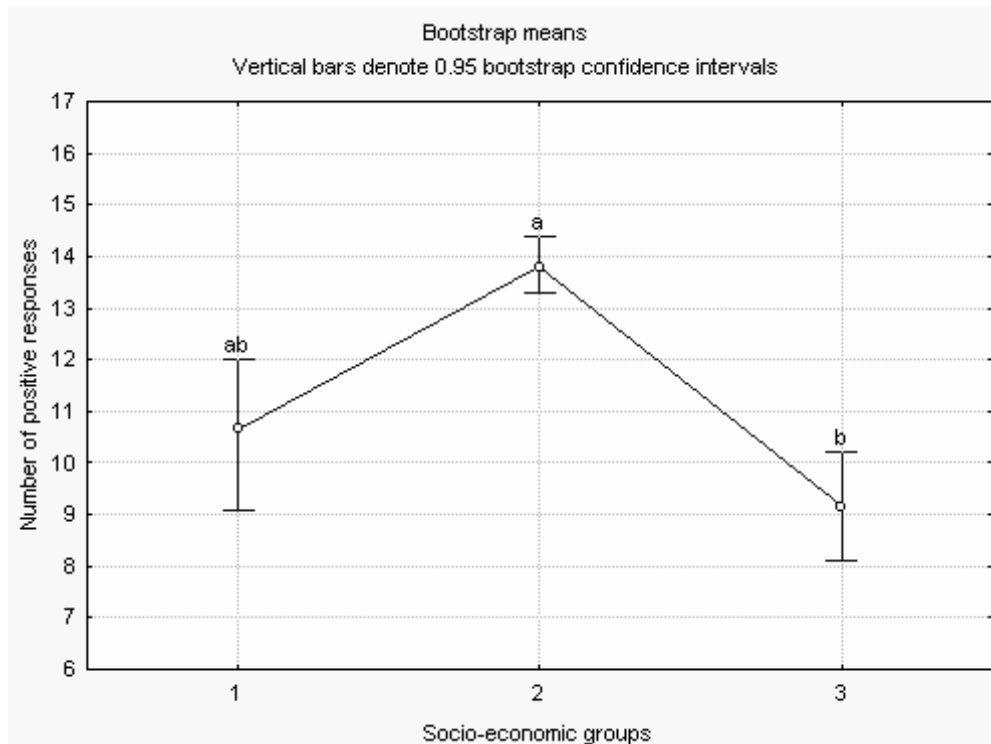
#### **5.7.2.2 Analysis of responses between socio-economic groups for all criteria**

To try and analyse the possible effect of socio-economic status only, language and gender differences were controlled and analyses were performed on the following filtered groups:

- Afrikaans girls;
- English girls;
- Afrikaans boys;
- English boys.

Where chi-square tests indicated significant differences among the responses, a non-parametric bootstrap one-way ANOVA was performed to verify the results and to detect where the differences were. A bootstrap analysis is performed when the normal probability plot of raw residuals indicates a non-normality of the residuals. For more information on one-way ANOVA, see Milton and Arnold (1990: 468 –457). For more information on Bootstrap, see Efron and Tibshirani (1993).

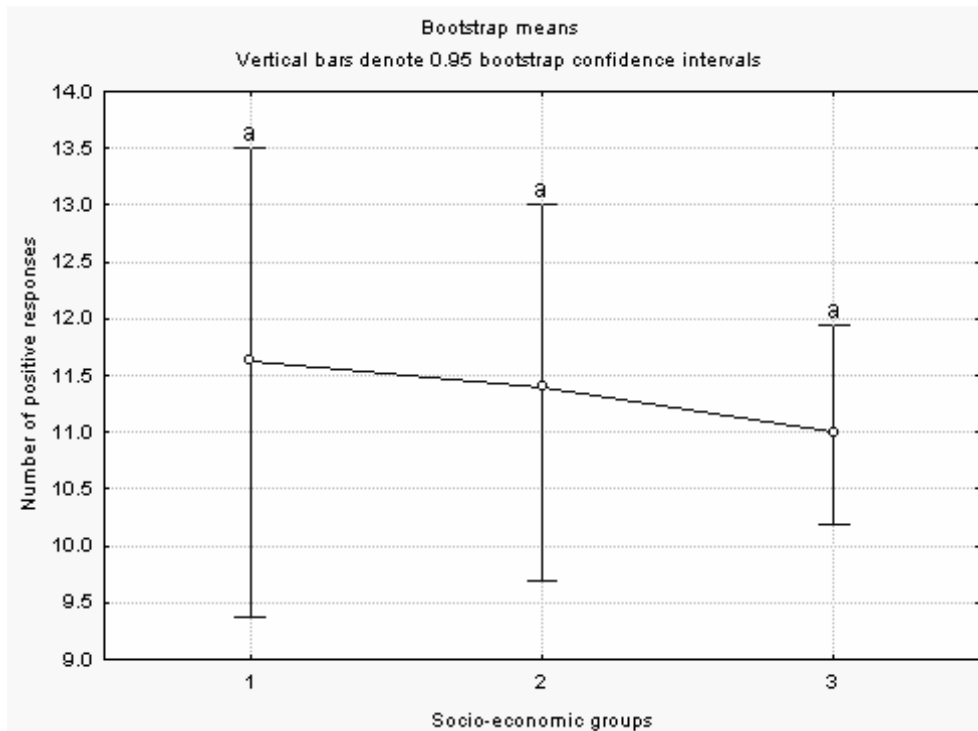
A significant difference was found for Afrikaans girls:  $X^2(24) = 43,1$ ;  $p = 0,0097$ . The bootstrap multiple comparisons showed a significant difference between socio-economic groups two and three ( $p = 0,000000$ ). This can be seen in the following diagram.



**Figure 15: Bootstrap multiple comparisons between socio-economic groups for Afrikaans girls on all criteria**

The labels above the vertical bars indicate where significant differences occur. The “a” and “b” labels above vertical bars 2 and 3 indicate that socio-economic groups two and three are significantly different (therefore two different labels). The “ab” label above vertical bar 1 indicates no significant difference between socio-economic group one and the other two groups.

No significant differences were found for either English girls, ( $X^2(16) = 16,7$ ;  $p = 0,4.$ ) or for Afrikaans boys, as can be seen from the bootstrap results in the following diagram.



**Figure 16: Bootstrap multiple comparisons between socio-economic groups for Afrikaans boys on all criteria**

The chi-square test for English boys showed a significant difference as well:  $X^2(24) = 37,1$ ;  $p = 0,04$ . Nothing could be said about socio-economic group three as there were only two English boys in this group. The difference between groups one and two could, however, clearly be seen from the summary frequency table in Figure 17 showing that 75,9% ( $n = 29$ ) of boys in group 1 responded positively more than 11 times compared to only 39,5% ( $n = 38$ ) in group 2.

	all 3	all 4	all 5	all 6	all 7	all 8	all 9	all 10	all 11	all 12	all 13	all 14	all 15	Row Totals
1	2	0	0	2	1	1	1	0	0	1	3	14	4	29
2	0	1	2	1	3	2	4	4	6	3	7	5	0	38
3	0	0	0	0	0	0	0	1	0	0	1	0	0	2
All Groups	2	1	2	3	4	3	5	5	6	4	11	19	4	69

**Figure 17: Summary frequency table for responses between socio-economic groups for English boys on all criteria.**

In summary, it appears that socio-economic group two for Afrikaans girls seemed much more positive than group three, whereas English boys in socio-economic group one also seemed much more positive than those in group two. It would therefore seem that socio-economic background could play a role in responses, but that the interplay between

gender, language and socio-economic status make it hard to explain why these differences occur where they do.

One may expect that the greater negativity in socio-economic group three could be due to gender as school G (in socio-economic group three) is a girls-only school. To shed more light on the effect that gender could have, the same processes as for socio-economic groups were followed.

#### **5.7.2.3 Analysis of responses between gender groups for all criteria**

Analyses were performed on the following filtered groups;

- English speakers from socio-economic group 1;
- Afrikaans speakers from socio-economic group 1;
- English speakers from socio-economic group 2;
- Afrikaans speakers from socio-economic group 2;
- English speakers from socio-economic group 3;
- Afrikaans speakers from socio-economic group 3.

Significant differences could be established in one instance only. The difference was found amongst English speakers of socio-economic group two:  $X^2(11) = 20,9$ ;  $p = 0,03$ . 73,7% ( $n = 19$ ) of the girls responded positively more than 11 times compared to 39,5% ( $n = 38$ ) of the boys. As socio-economic group three did not show any significant difference between boys and girls, one could not conclude that the more negative response that was found in socio-economic group three was due to the girls-only school being more negative.

The question of whether language preference affected the responses was also investigated.

#### **5.7.2.4 Analysis of responses between language groups for all criteria**

Once again the analyses filtered on specific groups to control the effect of gender and socio-economic background. The filtered groups were:

- Girls from socio-economic group 1;
- Boys from socio-economic group 1;
- Girls from socio-economic group 2;



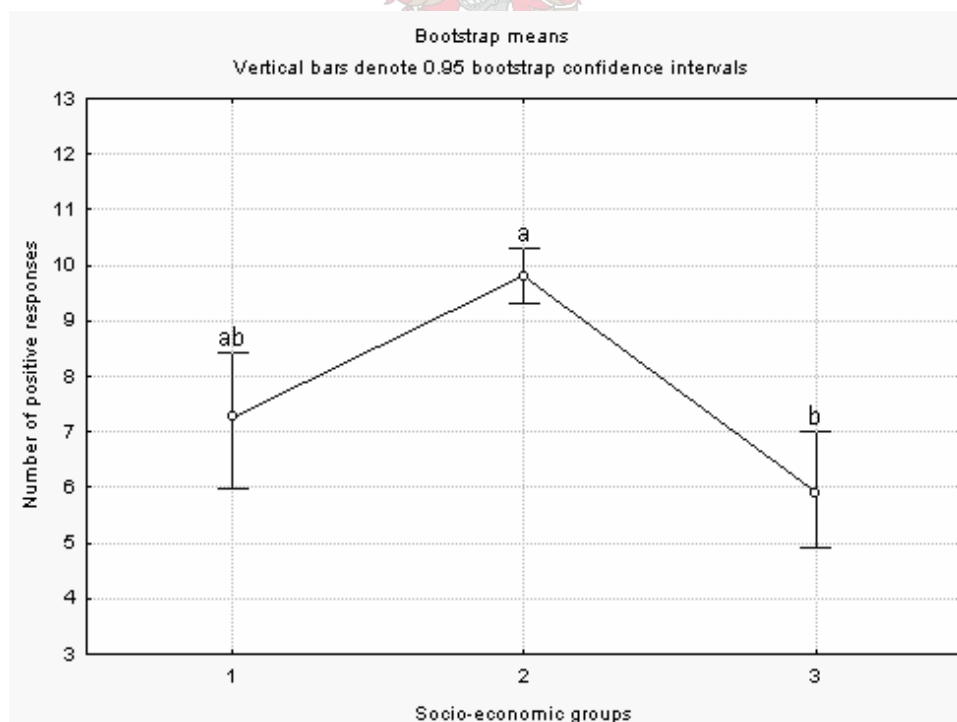
- Boys from socio-economic group 2;
- Girls from socio-economic group 3;
- Boys from socio-economic group 3.

None of these groups showed any significant differences in responses. The question is now whether the analyses would show similar results if one focused on didactical and visual criteria only. This question is addressed in the next section

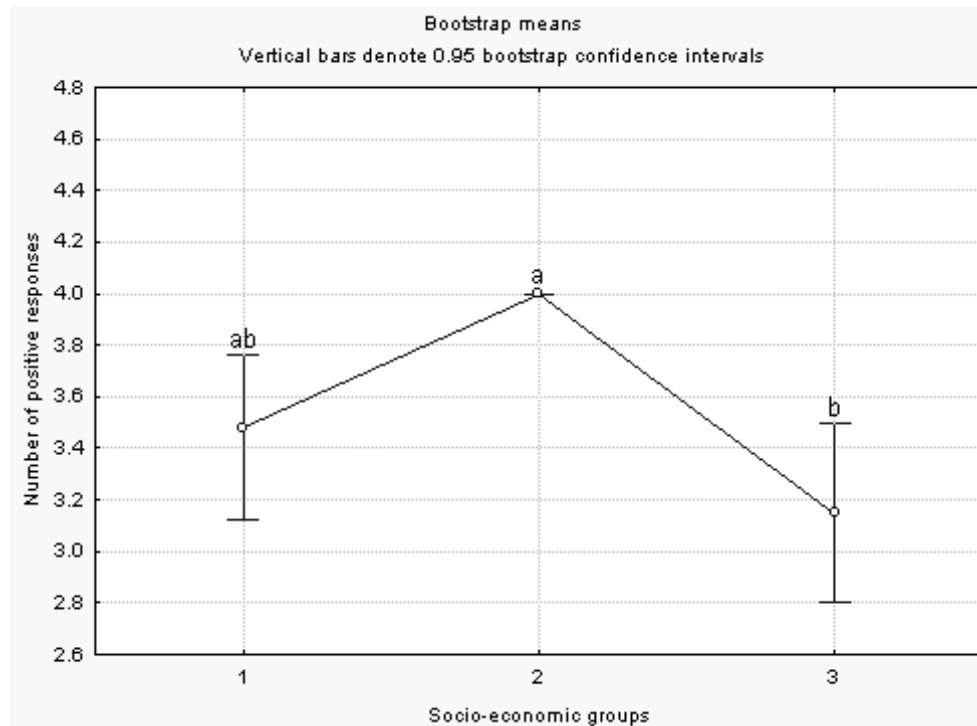
### 5.7.3 Analyses of quantitative data for all didactical and visual criteria

The same analyses that were done on all criteria, as reported in the previous section, were also done on all didactical and all visual criteria.

Significant differences between socio-economic groups were once again found for Afrikaans girls. The following two diagrams represent the results for the bootstrap analyses. Just as with the analysis for all criteria, we find significant differences between socio-economic groups two and three again. For all didactical criteria  $p = 0,000000$  and for all visual criteria  $p = 0,015$ .



**Figure 18: Bootstrap multiple comparisons between socio-economic groups for Afrikaans girls on all didactical criteria**



**Figure 19: Bootstrap multiple comparisons between socio-economic groups for Afrikaans girls on all visual criteria**

No other significant differences could be found to highlight socio-economic influence for responses to all didactical and all visual criteria.

The influence of gender was once again only found amongst English speakers of socio-economic group two and only for all didactical criteria:  $X^2(10) = 19,5$ ;  $p = 0,03$ . It was found that 73,7% ( $n = 19$ ) of the girls answered positively more than 8 out of a possible 11 times (more than 70% of questions). For the boys ( $n = 38$ ) the percentage is 39,5%.

Once again no significant differences could be found between responses of different language groups.

In summary, it could be said that it would seem that responses for all criteria did not differ from responses for didactical or visual criteria. It would also seem that socio-economic differences played a bigger role for Afrikaans girls than for any other group and that differences in responses between gender groups were more apparent for English speakers of socio-economic group two.

In the following section the responses are presented for each criterion. Data produced by responses from learners and teachers or from researcher observation are given separately. Summaries of positive and negative motivations are given for easy reference.

#### 5.7.4 Didactical Considerations

##### 1. Relevance of software to the curriculum.

###### Learner data:

- a) Do you feel that you are being better prepared through the use of this method or not? Motivate your response. (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 47)	95.7	2.1	2.1
B (n = 7)	85.7	0.0	14.3
C (n = 9)	77.8	22.2	0.0
D (n = 5)	100.0	0.0	0.0
E (n = 23)	100.0	0.0	0.0
F (n = 35)	65.7	25.7	8.6
G (n = 54)	63.0	16.7	20.4
H (n = 52)	90.4	3.8	5.8
All (n = 232)	81.9	9.9	8.2

**Table 9: Breakdown of responses for Question 12 of Piloting Stage Learner Questionnaire**

**Key:**

	Greatest financial need (Group 1)
	Middle income group (Group 2)
	Affluent areas (Group 3)

The only significant difference between socio-economic groups was found for Afrikaans girls  $X^2(2) = 6,8$ ;  $p = 0,03$ . Frequency of responses from socio-economic groups one and two were more positive than expected and those from group three were less positive than expected. No significant differences were found for language or gender groups.

Motivations received for this question are given in Table 10.

Positive motivations	Frequency	Negative motivations	Frequency
It was interesting / different / fun	3	Slides in the notes must be bigger	1
It was easier to understand	31	Notes are impersonal	1
It was aesthetically better	1	Prefer to make own notes in class	2
It was easy to follow – knew where it was going	2		
Liked the multimedia learning / animations	3		
It is easier to learn from images	2		

**Table 10: Positive and negative motivations for Question 12 of Piloting Stage Learner Questionnaire**

Of the 190 responses received, 31 learners said that it was easier to understand. Eight of those responses came from schools F and G. Although the number may not seem significant, it represents 8,9% of the responses from those two schools and 25,8% of the 31 learners that said it was easier. Although some of the learners in schools F and G do not feel that they are being prepared better by the CAIR, the majority state that they are (see percentages in Table 9) and 8,9% express the view that it is easier. It would seem that the CAIR could also serve schools in more affluent socio-economic areas well.

The indication that 81,9% of the total number of responses is positive means that learners generally feel better prepared when being taught with the aid of the CAIR.

Only three different motivations for negative responses were given by four learners from the eight schools. Frequencies of the motivations are shown above. The relatively large negative response percentage from schools C, F and G calls for further investigation. Motivations received from schools C and G indicate that learners felt that the teacher is

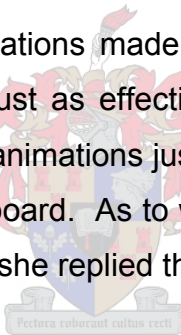
adequate and that the software therefore did not improve their experience. To shed some light on the responses from school F, it was decided to identify the learners from the questionnaires and then to interview them. Five learners from this school were interviewed. Conversations were recorded and I made notes while learners were interviewed. This same process was used to clear up responses for questions 2, 7, 10 and 16 (see interview results under the discussion of these questions). As two learners from school H were also identified as having given indecisive negative responses, I decided to interview them as well.

### **Interview Results for Question 12 of Piloting Stage Learner Questionnaire**

#### **School F:**

Learners were asked if their negative responses meant that their preparation was worse or the same.

Learner A stated that, although animations made it easier to understand the issue, the teaching could probably have been just as effective on the board. She felt that it was somehow harder to ask questions as animations just ran on and did not go step by step as when a teacher would draw it on the board. As to whether this actually made her feel that she was being prepared better or not, she replied that it was not better or worse.



Learner B stated in the interview that it was not a matter of preparation being worse, but that she was actually referring to the notes not being the only resource that one could learn from. She had to use her textbook as well. Her response therefore did not refer to the use of the resource in the classroom, but to the use of notes. She had also decided to use the textbook for extra information and was not necessarily prompted by her teacher to do so. This phenomenon warns us that when notes are used in conjunction with an audiovisual resource, teachers clearly have to inform learners what else except notes should be used during preparation. The intention with the CAIR was not that it would be the only resource for teachers to use or learners to learn from. Learners received notes to save them from having to copy anything down from the TV. It is up to the teacher to give extra examples, notes or references to other resources. When a resource like the CAIR is therefore distributed, it should be made clear to both teachers and learners that they should make use of other resources as well, that the resources help to structure lessons and that notes serve as a summary of what needs to be learnt.

Learner C stated that he did not feel that the preparation was better or worse, but the same. He usually consulted more than one source during preparation.

Learner D did not like computers and felt that it did not really make a difference. She felt that her preparation with or without the resource would have been the same. She added that the notes provided a very handy summary for use just before the exam.

Learner E replied that the experience helped preparation to a certain degree, as it was better to see things on the PC than on a chalkboard. He also added that the speed of the computer was a problem as it was too slow. This was a response from many of the learners at this specific school.

#### **School H:**

Learner A responded that she was used to underlining in a textbook. This method was different and made her feel that her preparation was worse.

Learner B felt that the preparation was not as good as with other topics as the teacher ran through the section too fast. She felt that it would have been better if the teacher were used to teaching with it. This is a very important observation from a learner as the CAIR does make it possible to run through content too quickly. This could be a problem for the inexperienced teacher. The pace at which a teacher works, though, is not controlled by the computer, but rather by the teacher. Unfortunately the teacher was not available for an interview, as she had left teaching at the end of the previous year.

#### **Teacher data:**

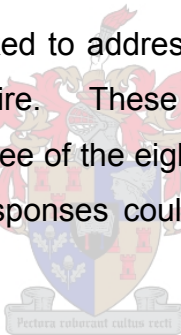
- b) Did you find the content to be correct, comprehensive and relevant to the curriculum? If not, please indicate the shortfalls. (T) (**Question 9: Piloting Stage Teacher Questionnaire**)

Five of the eight teachers simply answered that the content was correct. One remarked that only the section on graphs was different to the way it was usually taught in their school as learners lacked the mathematical knowledge. One teacher remarked that, although some of the content was in a different order, it was no problem as the software was adaptable to be used in the order that one wanted to.

It was felt that these responses could mean that some teachers felt that the CAIR was comprehensive enough and that they did not need to use any other resources in the classroom. However, the CAIR was intended to be a resource in initially introducing topics to the learners. Teachers still needed to introduce more examples and exercises as well as practical activities into their teaching strategies. From the responses it was not clear whether teachers were relying on the CAIR too heavily as a complete resource in their teaching.

It was therefore decided that these issues needed some clarification. As there were two other questions on the teachers questionnaire (see discussion for questions 8 and 10 of the Piloting Stage teacher questionnaire on p. 164 and p. 152 respectively) that needed clarification it was decided to draw up a final questionnaire for the teachers that would attempt to clarify these issues.

The following two questions were asked to address issues surrounding question 9 of the Piloting Stage Teacher Questionnaire. These questions are presented with their responses. It should be noted that three of the eight teachers that were originally involved in the testing had left teaching. Responses could therefore only be obtained from the remaining five.



#### **Clarification of responses to question 9 of Piloting Stage Teacher Questionnaire**

a) Did you need to use other resources except the CAIR to deliver content to the learners? (This question refers to theory only and not to the use of exam-type questions in classroom discussions.) If you used other resources, please state what you used.  
**(Question 4: Final Teacher Questionnaire)**

All five teachers responded that they used other resources as well. These included text books, transparencies and their own notes. The following question explored the issue further:

b) If you used additional resources, please state why? (e.g. maybe you found content in the CAIR to be incorrect, irrelevant or not comprehensive enough – or maybe you just prefer to use more than one resource. If you identified problems with content in the CAIR,



please identify the sections that were lacking) (**Question 5: Final Teacher Questionnaire**)

Reasons given were varied. One teacher wanted to extend the brighter learner in the classroom and therefore felt it necessary to use additional resources. Another teacher preferred to explain some of the problems differently. Two of the teachers felt that they just wanted to complement the CAIR and add a personal touch. The fifth teacher preferred the way that another textbook gave definitions.

From these responses it became clear that teachers understood that the CAIR was not meant to be a comprehensive resource. It was understood that they had integrated other resources into their teaching strategies as well.

## 2. The effect on learner attitudes and edutainment value (enjoyment of the lesson) in keeping their attention.

**Learner data:**

- a) Did you like or dislike the computer-based presentation method? Motivate your answer. (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 47)	95.7	4.3	0.0
B (n = 8)	100.0	0.0	0.0
C (n = 21)	95.2	4.8	0.0
D (n = 19)	94.7	5.3	0.0
E (n = 24)	100.0	0.0	0.0
F (n = 36)	94.4	5.6	0.0
G (n = 60)	90.0	6.7	3.3
H (n = 58)	93.1	6.9	0.0
All (n = 273)	94.1	5.1	0.7

**Table 11: Breakdown of responses for Question 1 of Piloting Stage Learner Questionnaire**

No significant differences were found between socio-economic, gender or language groups for this question.

Motivations received for this question are given in Table 12.

Positive motivations	Frequency	Negative motivations	Frequency
It was interesting / different / fun	72	More examples wanted	1
It was easier to understand	85	Hard to understand	1
Aesthetically better	11	Would like audio as well	1
It was easy to follow – knew where it was going	7	Want a bigger TV or a projector	6
Liked the multimedia learning / animations	13	Want resource in Afrikaans	6
Easier to see what was happening/not just talking	11	Computer is too slow	5
Saved time as there was no need to make notes	3	Teacher went too fast	4
It is easier to learn from images	2		
Structure saves time / makes teacher's job easier	9		
It was interesting / different / fun	72		

**Table 12: Positive and negative motivations for Question 1 of Piloting Stage Learner Questionnaire**

It is interesting to note that even though the question is not trying to test whether the CAIR made it easier (it is rather testing if learners liked it or not), 33% of the positive responses stated that it was easier. This was also the positive motivation given most often in the previous question. If one looks at this response for the whole group (276 learners) for all the questions, the response comes up 190 times.

The other positive response that is quoted very often is the one that says it was different, interesting or more fun. In this specific question it came up 72 times. In total for all learners in all questions it came up 154 times. It would therefore seem that the two main reasons why learners like the CAIR are because they experience it to be (a) more entertaining and (b) easier to understand.

This positive response of 94,1% overall means that the majority of learners liked it.

The motivations given above address some important issues that will be discussed further in Chapter 6 (see p. 180).

- b) Did you find this method more entertaining than other teaching methods that you have encountered? Motivate your answer. (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 46)	93.5	6.5	0.0
B (n = 8)	75.0	25.0	0.0
C (n = 20)	85.0	15.0	0.0
D (n = 18)	94.4	5.6	0.0
E (n = 24)	95.8	4.2	0.0
F (n = 35)	71.4	22.9	5.7
G (n = 58)	81.0	17.2	1.7
H (n = 57)	94.7	3.5	1.8
All (n = 266)	87.2	11.3	1.5

**Table 13: Breakdown of responses for Question 5 of Piloting Stage Learner Questionnaire**

**Key:**

	Greatest financial need (Group 1)
	Middle income group (Group 2)
	Affluent areas (Group 3)

A significant difference in response was found between socio-economic groups for Afrikaans girls  $X^2(2) = 6,8$ ;  $p = 0,03$ . Girls from socio-economic groups one and two were again significantly more positive than predicted by the expected values and group three was less positive.

Motivations received for this question are given in Table 14.

Positive motivations	Frequency	Negative motivations	Frequency
It was interesting / different / fun	21	Hard to understand	1
It was easier to understand	13	Teacher went too fast	1
Aesthetically better	5		
Liked the multimedia learning/animations	1		
Easier to see what was happening / not just talking	4		
Structure saves time / makes teacher's job easier	2		

**Table 14: Positive and negative motivations for Question 5 of Piloting Stage Learner Questionnaire**

It was again insightful to see how many learners responded that it was easier to understand, even though the question did not address the issue of understanding. This response seems to come up very often and one wonders whether they really understand better. As it was not the aim of this study to investigate understanding of learners quantitatively (see Chapter 2 for discussion of methodology), it is important to note that the claim is not made that learners actually do understand better. However, one can deduce that the majority of learners believe that they understand better. This positive attitude towards the CAIR is an important result of this investigation. The 87,2% positive response reinforces the observation that learners are positive about the CAIR.

### 3. Contribution to teaching process in terms of structuring the lesson.

#### Learner data:

- a) Do you think the lesson was more structured (better organised) than others that you have experienced before? Please say why it was or why it was not. (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 46)	93.5	4.3	2.2
B (n = 6)	66.7	33.3	0.0
C (n = 14)	85.7	14.3	0.0
D (n = 15)	93.3	0.0	6.7
E (n = 24)	100.0	0.0	0.0
F (n = 35)	57.1	37.1	5.7
G (n = 57)	42.1	29.8	28.1
H (n = 54)	92.6	5.6	1.9
All (n = 251)	76.1	15.5	8.4

**Table 15: Breakdown of responses for Question 7 of Piloting Stage Learner Questionnaire**

**Key:**

	Greatest financial need (Group 1)
	Middle income group (Group 2)
	Affluent areas (Group 3)

Significant differences in responses were found for a number of different groups. Differences in responses between socio-economic groups were found for Afrikaans girls  $X^2(2) = 8,0$ ;  $p = 0,02$  and Afrikaans boys  $X^2(2) = 13,7$ ;  $p = 0,001$ . For both these groups the responses from socio-economic groups one and two were much more positive than expected and the response from group three was much less positive than expected. A difference in response between language groups was also found for boys in socio-economic group two  $X^2(1) = 7,2$ ;  $p = 0,007$ . The English speakers were more positive than the Afrikaans speakers. Although one may want to deduce from this that this difference in responses is owing to the CAIR being in English only, no significant differences were found in any of the other five groups (grouped on grounds of gender and socio-economic group) that were analysed for differences due to language factors.

Motivations received for this question are given in Table 16.

Positive motivations	Frequency	Negative motivations	Frequency
It was interesting / different / fun (8)	8	Slides in the notes must be bigger	1
It was easier to understand (8)	8	Prefer to make own notes in class	2
Aesthetically better (3)	3	Want audio as well	1
It was easy to follow (straight forward) – knew where it was going - starts easily and progresses (22)	22	TV was too low	1
Liked the multimedia learning/animations (3)	3		
Easier to see what was happening/not just talking (1)	1		
Saved time as there was no need to make notes (2)	2		
Structure saves time/makes teacher's job easier (7)	7		

**Table 16: Positive and negative motivations for Question 7 of Piloting Stage Learner Questionnaire**

Some of the positive motivations did not directly address the issue of structure in the question. The percentage positive response (76,1%) is now remarkably lower than some of the previous positive response percentages. This is indicated by the remarkably lower percentage positive response in schools F and G. Learners in school G indicated that their teacher was good at structuring their lessons. This was consistent with the teacher responding that she had structured the use of the CAIR to fit in with her lessons. The negative responses from learners in school F needed some further investigations. Interviews were held to clear up this issue. Six learners in school F were interviewed.

Another learner in school A that needed to be interviewed on the same matter was also identified. The results of these interviews are reported below.

School B also indicated a noticeably lower positive response percentage. This could most likely be due to this teacher not having totally integrated the CAIR with the lessons. He also used his own notes. This leaves one with the impression that students experienced the CAIR as only a minor resource in the lesson.

It is equally important to note that 5 of the schools (A, C, D, E, H) show very high positive response percentages. Two motivations need special mention. The first is the indication that learners found the CAIR easy to follow (straightforward) – knew where it was going - starts easily and progresses (22 responses for this question, 45 for all questions). The second is that learners indicated that the structure saves time/makes teacher's job easier (7 responses for this question, 23 for all questions). These aspects must have been significant to the learners that mention them, as these are their own motivations.

Once again there is a very low frequency of responses for the negative motivations. The motivations also do not directly address the issue of structure in the question.

### **Interview results for Question 7 of Piloting Stage Learner Questionnaire**

#### **School A:**

Learners were asked if their negative responses meant that the structuring was the same as always or worse.

The learner from school A did not really address issues surrounding structuring of the lesson and it took some explanation from me to clarify what was meant. She then concluded that the teacher did not necessarily teach better with the CAIR. She also stated that the computer made it more interesting and that it helped to keep one's attention.

#### **School F:**

Learner A said that structure of lessons was worse. This was due to the computer being too slow or "getting stuck". She also said that this resulted in a discipline problem in the classroom.



Learner B said that he could not really remember why he stated that the lessons were not structured better. He felt that things were a bit disjointed as the teacher used mixed media to teach. She would work on the PC and then on the board, which made things seem less organised. He was full of praise for the CAIR though. He stated that the CAIR did not break down the structure of the lesson and that it was a nice addition to the lesson.

Learner C mentioned that the PC was slow and that this wasted time between slides. He emphasised, though, that he actually thought that the lesson structure had improved with the use of the CAIR.

Learner D stated that the structure was the same as always. She complained that the teacher was jumping around between the board and the PC and also between topics. However, the structure was not worse than usual.

Learner E answered that the teacher used the board, overhead projector as well as CAIR. This jumping around between different media negatively affected the structure of the lesson.

Learner F seemed to have misinterpreted the question initially. He stated in the interview that the CAIR did not improve the structure or affect it negatively. He seemed to want to emphasise that a teacher is still needed to add in extra information.

### **Researcher observation:**

- b) Integration with other media: Is the teacher using the resource simply as a resource or does it become the only thing that the teacher does? Does the software therefore become too dominant in the delivery of new learning material?  
(R)

There was only one teacher who did not integrate the CAIR well with other media. This teacher needs special mentioning due to the unique circumstances at that school. The teacher that had originally come for training left the school before starting implementation of the CAIR. This teacher was replaced by a retired teacher who had to make a 200 km round trip to school everyday. He had never used a computer before and when it came to the school visit he was still trying to figure out what to do. I spent about three minutes showing him what to do and then observed the class. He coped extremely well and could

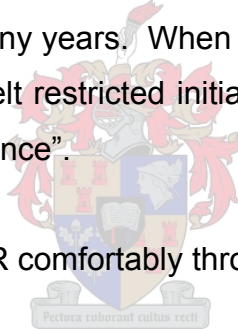
easily use the mouse and control the animations. He was very positive about it and had high praise for the resource. Because this was the first time he used the CAIR, he did not use other media at all as he was familiarising himself with the use of the CAIR.

The other teachers all coped very well and integrated the CAIR with other media in a natural and fluent manner.

- c) Integration into the structure of the lesson: Is the resource something that the teacher uses before or after he/she has taught the lesson or does it form an integrated entity with the lesson? (R)

Only one teacher did not integrate the CAIR fully into the structure of the lesson. This teacher used it only to show animations and always referred to it after he had already discussed something. It was clear that this teacher preferred to use the CAIR as a reinforcement tool only. His students did not receive the printed notes either, but rather notes that he had been using for many years. When reading the teacher's response in his questionnaire he said that he had felt restricted initially, but later realised that it was very useful and "managed to strike a balance".

The other teachers all used the CAIR comfortably throughout the lesson.



#### **Teacher data:**

- d) Do you think this resource could help you in structuring your lesson? (T)  
(Question 3: Training Stage Teacher Questionnaire)

This question was asked after the teachers had gone through the Training Stage. All the teachers answered positively that it could help them in structuring their lessons. Two of them remarked that it would need to be well planned and two of them remarked that they just needed to add a few examples to individualise the resource.

- e) Did the software help you to structure your lessons? (T) (Question 4: Piloting Stage teacher Questionnaire)

This question was asked after the Piloting Stage to see if teachers felt that the resource did really help as much in structuring the lessons as they had anticipated that it would. The responses were as follows:

- One teacher simply said yes;
- Three teachers said that they structured lessons around the software. One of them remarked that it saved time;
- One remarked that the CAIR probably structured his lessons too much (he had twenty years of teaching experience);
- One teacher remarked that she used the software to fit in with her structure;
- One remarked that it did not influence the structure, as it was the way that she taught anyway;
- One remarked that he used his own structure as he had many years' experience and did not comment on how the CAIR fits in with his structure.

These responses show that the CAIR has value in structuring lessons, but is not so prescriptive that teachers who wanted to use it within their own structure could not do so.

#### **4. Effectiveness as a timesaver for the teacher.**

##### **Teacher data:**

- a) Do you think that this resource could help save you time in the classroom? If so, in what sense? (T) **(Question 2: Training Stage teacher Questionnaire)**

This question was asked after the Training Stage. The responses were as follows:

- Two teachers answered affirmatively and added that learners now have a set of notes and that time will not be wasted by them copying notes in class;
- Three teachers responded that it would save time as some difficult illustrations and demonstrations had been included in images and animations;
- One said that it would save the time used in preparing new transparencies and in revision;
- One said that she would be more focused and that it would therefore save time;
- One was not sure but said that the resource gave a good structure.

It would therefore seem that seven out of the eight teachers expected the CAIR to save them time. The next question was asked after the Piloting Stage.

b) Did the use of the software help save you time in the classroom. Why? (T) (**Question 3: Piloting Stage Teacher Questionnaire**)

Only one of the teachers was not totally positive about the time-saving possibility of the CAIR. She answered yes and no, and motivated her response by saying that the notes saved time, but the computer was too slow, especially during animations. This was the teacher from school F, where the learners had also complained about the speed of the computer (four of the five negative motivations on p. 96 referring to a slow computer came from school F). The other seven teachers were all positive about the time-saving aspect and reasons given were as follows:

- Animations meant less time wasted to try and explain on a chalkboard;
- It made it easy to go back to a section to revise what they need to know if they do not understand something new;
- Learners did not have to take notes;
- Less time was spent on lesson preparation as it offers a more structured approach to preparation;
- Saved time making transparencies;
- Saved time as a quick crash course for revision just before the exams;
- Illustrations made concepts clearer to learners and saved time.

## 5. Integration with TRAC system.

Schools C and G had not used the TRAC practicals and therefore show a zero response frequency in questions 13 to 16.

### Learner data:

a) Did the use of the TRAC system for practicals help you to understand the concepts in those practicals better? (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 46)	95.7	4.3	0.0
B (n = 6)	100.0	0.0	0.0

School	% Positive Response	% Negative Response	% Neutral Response
C No responses			
D (n = 15)	93.3	6.7	0.0
E (n = 24)	100.0	0.0	0.0
F (n = 35)	85.7	11.4	2.9
G No responses			
H (n = 55)	100.0	0.0	0.0
All (n = 181)	95.6	3.9	0.6

**Table 17: Breakdown of responses for Question 13 of Piloting Stage Learner Questionnaire**

No significant differences were found in the responses between any of the socio-economic, gender or language groups for this question. Due to the nature of the question, learners did not motivate their responses. One said that the TRAC practicals were hard to understand. The 95,6% positive response percentage shows that learners felt that the TRAC practicals did make it easier to understand concepts.

b) Did you like or dislike the format of the practical sheets that you had to complete? If you choose dislike, please say how you would improve it. (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 47)	95.7	4.3	0.0
B (n = 2)	100.0	0.0	0.0
C No responses			
D (n = 10)	90.0	0.0	10.0
E (n = 23)	100.0	0.0	0.0
F (n = 36)	83.3	13.9	2.8
G no responses			
H (n = 54)	98.1	1.9	0.0

School	% Positive Response	% Negative Response	% Neutral Response
All (n = 172)	94.2	4.7	1.2

**Table 18: Breakdown of responses for Question 14 of Piloting Stage Learner Questionnaire**

No significant differences were found in the responses between any of the socio-economic, gender or language groups for this question. Learners once again failed to give motivations for their responses. Five learners said that the sheets were difficult to understand. One of them came from school A and four from school F. The 94,2% positive response percentage shows that learners generally liked the practical sheets.

- c) Did you work in groups and did that make it harder for you to benefit from the practical? (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 47)	97.9	2.1	0.0
B (n = 1)	100.0	0.0	0.0
C No responses			
D (n = 1)	100.0	0.0	0.0
E (n = 23)	100.0	0.0	0.0
F (n = 30)	96.7	3.3	0.0
G No responses			
H (n = 54)	98.1	1.9	0.0
All (n = 156)	98.1	1.9	0.0

**Table 19: Breakdown of responses for Question 15 of Piloting Stage Learner Questionnaire**

No significant differences were found in the responses between any of the socio-economic, gender or language groups for this question. Most learners answered the

question by saying both “yes” and “no”. They said “yes” to working in groups and “no” to it making it harder to benefit. This response was taken as positive. The response was only coded as negative if learners said that group work made it harder. If learners reported that they did not work in groups it was not coded as positive, negative or neutral but reported under a separate heading. Thirty-three learners reported that they had not worked in groups.

Motivations received for this question are given in Table 20.

Positive motivations	Frequency	Negative motivations	Frequency
It helps to discuss in groups	38	Harder to work in groups	2
		Hard to understand	1

**Table 20: Positive and negative motivations for Question 15 of Piloting Stage Learner Questionnaire**

The 98,1% positive response rate leads one to believe that learners prefer working in groups.

d) What did you dislike about the TRAC system? (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 35)	88.6	11.4	0.0
B (n = 5)	60.0	40.0	0.0
C No responses			
D (n = 6)	100.0	0.0	0.0
E (n = 17)	100.0	0.0	0.0
F (n = 10)	90.0	10.0	0.0
G No responses			
H (n = 20)	100.0	0.0	0.0
All (n = 93)	92.5	7.5	0.0

**Table 21: Breakdown of responses for Question 16 of Piloting Stage Learner Questionnaire**



A positive response meant that respondents did not indicate any dislike. No significant differences were found in the responses between any of the socio-economic, gender or language groups for this question.

Motivations received for this question are given in Table 22.

Positive motivations	Frequency	Negative motivations	Frequency
Disliked nothing	85	Hard to understand	1
Easier to understand	1	Would like audio as well	2
Want chemistry as well	3	Dull and boring	1
		Not enough time for pracs	1
		Want it in Afrikaans	3
		Computer too slow	10

**Table 22: Positive and negative motivations for Question 16 of Piloting Stage Learner Questionnaire**

The TRAC practicals are available in Afrikaans, but the software that integrates with the detectors is in English only. However, learners may have been referring to the CAIR rather than the TRAC practicals, but this was not clear. The three learners who said they wanted it in Afrikaans were identified. Two of them were in school A and one was in school F. These learners were interviewed and all three of them indicated that they had actually referred to the CAIR.

It is interesting to note that the ten learners who complained about the computer being too slow did not all come from school F as could be expected from responses to previous questions. Only two learners from school F mentioned this; three came from school A and five from School H.

**Teacher data:**

e) How did you integrate the use of this resource with the TRAC system? Did you do specific practicals directly after the theory or did you leave it till later? (T) **(Question 16: Piloting Stage Teacher Questionnaire)**

- Three teachers responded that they leave the practicals till after the whole Mechanics section is completed. This included the schools that had not done the practicals at the time of completing the questionnaires.
- Three teachers simply indicated that they did not integrate, but did the theory with the use of the CAIR first.
- Two teachers indicated that they integrated the practicals with the CAIR.

It seems therefore that the majority preferred to do the practicals after theory had been discussed.

f) Did your learners perform the practicals in groups, individually or did you do a demonstration? (T) **(Question 17: Piloting Stage Teacher Questionnaire)**

- Two teachers reported doing group work.
- Two reported a combination of demonstration and group work.
- Four teachers reported demonstrations only.

g) What did you like and dislike about the TRAC system? (T) **(Question 18: Piloting Stage Teacher Questionnaire)**

- Four of the teachers offered no negative comments. Positive comments were that they liked the use of technology in the classroom and that the material was relevant to the syllabus. Graphs and reference points were clear.
- One complained that it was hard to obtain smooth graphs.
- Two teachers complained that it was time consuming.
- One teacher did not respond to the question.

**6. Effectiveness of the notes**

Two of the schools (B, C) did not use the notes that were supplied and school D seemed to supply them as an extra resource only because very few learners responded to

questions on the notes. School E copied the notes back to back and therefore did not have blank pages. School F reduced the notes to six slides per page and not the three that were supplied. Not all the schools therefore experienced the same format. This influenced the response from learners. It is understandable that schools would want to try and save costs and therefore reduce the size of slides or copy notes back to back.

### Learner data:

- a) Did you find the notes easy or difficult to study from? Please motivate your answer.  
(L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 47)	83.0	12.8	4.3
B No responses			
C No responses			
D (n = 3)	100.0	0.0	0.0
E (n = 23)	95.7	0.0	4.3
F (n = 34)	50.0	50.0	0.0
G (n = 49)	61.2	34.7	4.1
H (n = 55)	90.9	7.3	1.8
All (n = 211)	76.3	20.9	2.8

**Table 23: Breakdown of responses for Question 8 of Piloting Stage Learner Questionnaire**

**Key:**

	Greatest financial need (Group 1)
	Middle income group (Group 2)
	Affluent areas (Group 3)

Afrikaans girls in different socio-economic groups showed a significant difference in their response to this question  $X^2(2) = 15,2$ ;  $p = 0,0005$ . The same phenomenon was found for English girls  $X^2(2) = 6,5$ ;  $p = 0,0039$ . For both these groups, girls from socio-economic groups one and two were much more positive in their responses than expected, while girls from group three were less positive than expected. Significant differences were also found between responses from English and Afrikaans girls in socio-economic group three  $X^2(2) = 7,14$ ;  $p = 0,028$ . English girls were more positive than expected, while Afrikaans girls were less positive than expected. One may be tempted to deduce that this is owing to the notes

being in English only. There were, however, no significant differences between language groups in any other socio-economic group or gender group, which makes it seem that language preference did not play such a big role.

There is a very high negative response percentage from schools F and G. The reasons for this will be discussed below.

Motivations received for this question are given in Table 24.

Positive motivations	Frequency	Negative motivations	Frequency
Easier to understand	3	Want slides bigger	4
Aesthetically better	1	More examples of problems wanted	1
It was easy to follow – knew where it was going	2	Hard to understand	4
Did not need to make own notes	1	Prefer to make own notes in class	10
It was easy to follow (straight-forward) – knew where it was going - starts easily and progresses	6	Want more sources to study from	1
Easier to understand	3	Want it in Afrikaans	13

**Table 24: Positive and negative motivations for Question 8 of Piloting Stage Learner Questionnaire**

The two main complaints from school F were that they wanted the notes in Afrikaans (9) and that they wanted the slides bigger (4). The main complaint from school G was that they preferred to make their own notes in class (8).

It is surprising that not more learners from school F complained about the slide sizes as they had received the slides reduced to six slides on a page. The response about preferring to make their own notes seems to be peculiar to school G and may be

something that was reinforced by the teacher. It is also interesting to note that it is an all-girl school. It may be relevant to another study to investigate further whether this is a gender-based preference. The statistical analysis for this study did, however, not show any significant differences in the responses between gender groups.

- b) Did you use the blank pages next to the slides to take extra notes/examples off the board? (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 46)	65.2	34.8	0.0
B No responses			
C no responses			
D (n = 2)	100.0	0.0	0.0
E (n = 22)	63.6	36.4	0.0
F (n = 31)	74.2	25.8	0.0
G (n = 46)	37.0	60.9	2.2
H (n = 52)	73.1	26.9	0.0
All (n = 199)	62.3	37.2	0.5

**Table 25: Breakdown of responses for Question 9 of Piloting Stage Learner Questionnaire**

**Key:**

	Greatest financial need (Group 1)
	Middle income group (Group 2)
	Affluent areas (Group 3)

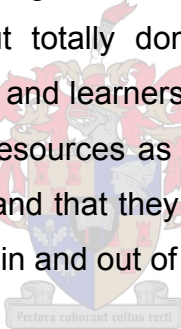
A significant difference was found in the responses between different socio-economic groups for Afrikaans boys  $X^2(2) = 11,4$ ;  $p = 0,0032$ . Socio-economic groups one and two were much more positive than expected, whereas group three was much less positive than expected. Similar to the previous question a significant difference was also found between English- and Afrikaans-speaking girls from socio-economic group three  $X^2(2) = 9,13$ ;  $p = 0,01$ . This time however, the Afrikaans girls were more positive than expected and the English girls were less positive than expected.

Although it is clear that the majority of the learners used the blank spaces for extra notes, it should be considered that learners could make notes elsewhere if needed. This would

mean a huge saving in printing cost. As the next question shows, many learners prefer to make notes next to printed information on the slides and therefore prefer the slides to be bigger than having blank pages to write on. As most schools will probably try and save money by printing on both sides of the page, it should probably be the choice of the school and therefore notes should be supplied with blank pages that they can then eliminate if they like.

c) What, apart from the notes, did you use to study from in preparation for tests and exams? (L) (**Question 10: Piloting Stage Learner Questionnaire**)

Fourteen learners said that they had studied from the notes only. One hundred and twenty-five learners said that they had studied from tutorials, past papers and other notes. One hundred and sixty-four said that they had also studied from a textbook as well. These responses leave one with the impression that teachers are using the notes as an extra resource only, therefore integrating the CAIR? with other resources to form part of the total learning experience without totally dominating it. This was not what was expected. The fear was that teachers and learners would lean on the notes too much and not do extra examples or use other resources as well. It also means that teachers have recognised the flexibility of the CAIR and that they feel free to still add their own personal touch to both the learning experience, in and out of the classroom.



The CAIR was not developed to be a totally comprehensive resource, but rather as an aid for teachers in the classroom. Judging from the previous paragraph, It seemed to have been successful in this sense. However, from the response of some learners in interviews referring to question 2 (see p. 148), it seemed that some of the learners in, for instance, school A expected the notes to be more comprehensive and therefore gave negative responses, as they needed to use the textbook as well. It was therefore now not clear whether this large number of responses stating that other resources had been used as well meant that learners thought the notes were of a low quality and inadequate. It was decided to try and clear this uncertainty up through interviews as well.

Five learners from school A, four from school F and two from school H were interviewed to establish the reasoning behind their responses.

**Interview results for Question 9 Piloting Stage learner Questionnaire****School A:**

Learners were asked why they used other resources besides the notes and whether this meant that the notes were not good enough.

Learner A did not use the notes and found it easier to work from a textbook.

Learner B used the notes to study for tests and exams. She consulted the textbook only to clear up some initial uncertainties. She said that she would use the notes in future to study from. She would also use extra notes from her class work.

Learner C used the notes to study from and other resources to obtain extra examples. She also said that she would use the notes again as they helped her to prepare.

Learner D stated that she preferred Afrikaans and would only use the notes to read through. She would rather study from her Afrikaans book.

Learner E also had a language problem with the notes. He would have preferred it in Afrikaans as he had a problem with terminology. He liked the way the notes summarised topics, though, and would use them to study from in future.

**School F:**

Learner A used additional notes out of habit and not because she felt the notes were inadequate. The teacher did not specifically tell them to use additional notes as well.

Learner B stated that she used the notes to study from and that she found them easy.

Learner C said that the notes were good. She used extra resources for extra insight. She said she would use the notes again together with her own notes.

Learner D used extra notes as she felt that she is not good at Science. She found that the notes were a very good resource for revision as it is a resource that saves time.



**School H:**

Learner A responded that she found the notes were sometimes not too clear. She used other resources only for the topics covered with the CAIR. One has to realise, though, that this learner seemed very bound by the textbook, judging by her answers on other questions in the interview.

Learner B replied that he used another resource, but that it was nothing out of the ordinary as he usually used extra resources. He found the notes to be good, but wanted another resource as well.

- d) Did you like the layout of three slides per page in the notes or would you have preferred it to be different? How would you have changed it? (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 46)	93.5	6.5	0.0
B No responses			
C No responses			
D (n = 3)	100.0	0.0	0.0
E (n = 23)	39.1	60.9	0.0
F (n = 28)	67.9	28.6	3.6
G (n = 46)	69.6	28.3	2.2
H (n = 48)	91.7	6.3	2.1
All (n = 194)	77.3	21.1	1.5

**Table 26: Breakdown of responses for Question 11 of Piloting Stage Learner Questionnaire**

No significant differences were found in the responses between any of the socio-economic, gender or language groups for this question. Only two different motivations were received from 44 learners. Both of them were negative (stating that they did not like

the three slides per page). If one considers these motivations (given below) it seems that they contradict each other.

Thirty-two learners (16,5% of the 194 that responded) stated that they wanted the slides bigger. The responses from individual schools were as follows:

- School A      2
- School D      1
- School E      15
- School F      10
- School G      2
- School H      2

Eleven learners (5,7% of the 194 that responded) stated that more slides on a page could save paper. Responses came from the following schools:

- School G      9
- School H      2



## 7. Correctness and comprehensiveness of content

### Teacher data:

- a) Did you find the content to be correct, comprehensive and relevant to the curriculum? If not, please indicate the shortfalls. (T) (**Question 9: Piloting Stage Teacher Questionnaire**)

The response to this question has already been reported under **Relevance of software to the curriculum** (see pp. 127 - 128).

- b) Were there enough, too few or too many examples in the resource? (T) (**Question 10: Piloting Stage Teacher Questionnaire**)

Two teachers responded that the examples were too few. Another said that examples were too few, but that he preferred to add his own. The other five all said that there were enough examples.

I also needed more examples in my own teaching. This was perhaps one of the more difficult aspects of the design. It was hard to design a resource for other teachers and to decide how many examples to put in. It would seem that teachers preferred to add their own examples. This makes it possible for the teacher to personalise the facilitation process to suit his or her own needs. If teachers do want more examples, it may be a better idea to provide a separate resource with more examples and not to make it part of the CAIR. From the responses given here, it seems that teachers are happy to add their own examples.

I felt that this issue needed some clarification. It was not clear if teachers thought that the given examples were enough in total or just enough as an initial introduction. I was particularly concerned that some teachers may only discuss the examples in the CAIR. This was not the intention with the design of the CAIR and would lead to learners not being adequately prepared. The following two questions in the Final Teacher Questionnaire explored these issues.

#### **Clarification of responses to Question 10 of Piloting Stage Teacher Questionnaire**

a) Some teachers stated that there were too few examples in the CAIR and some stated that there were enough. Did you feel that the number of examples was adequate as a first introduction to the content or would you have wanted more? **(Question 6: Final teacher Questionnaire)**

Three of the teachers wanted more examples and two felt that there were enough. The two who felt that there were enough examples stated that they preferred to supplement the CAIR with their own examples. One added that she preferred doing examples on the board as she felt it was easier for learners to follow. The other teacher also said that he preferred to add his own examples to differentiate between Higher Grade and Standard Grade and that more examples would make the CAIR too rigid.

The three teachers who wanted more examples did not motivate their response.

b) If you found that the number of examples in the CAIR was enough for an initial introduction, did you need to do any others later in class or did you feel that these

examples were chosen carefully enough to address all the necessary issues in Mechanics to prepare learners for tests and exams? (**Question 7: Final teacher Questionnaire**)

The three teachers that wanted more examples in the first question just reiterated the same statement. The other two teachers made it clear that they had added more examples and that they preferred to do so.

These responses show that teachers felt that more examples were needed than those given in the CAIR. It also made it clear that teachers are divided on the issue of having more examples as an initial introduction. I tend to agree with the teacher who stated that more examples could make the CAIR too rigid. Flexibility in the classroom is an important principle and it is felt that extra examples should therefore rather be included in a separate document.

#### **8. The amount of flexibility that the resource allows the teacher.**

##### **Teacher data:**

- a) Did the resource allow for enough flexibility or did you feel restricted by it? Please motivate. (T) (**Question 11: Piloting Stage Teacher Questionnaire**)

Seven of the eight teachers remarked that there was enough flexibility as they could add on easily by using an overhead projector or a chalk board, and that they could add their own examples.

One of the teachers remarked that he felt restricted by the CAIR, as he had his own method of teaching and had obtained good results in previous years. This teacher was the substitute teacher from school C that had not been through the training session. He also had very little prior experience of computers and, although he coped very well after only a few minutes of instruction during the school visit, he may not have felt as comfortable as the other teachers.

Although one cannot make any conclusive deductions from his response, it does indicate that training is probably needed. Support in the form of school visits is vital to determine and monitor the use of such a resource.

## 9. Way in which the content is presented and revealed to the learners.

### Teacher data:

- a) Did you like or dislike the way in which content was revealed and presented to the learners? If you disliked it, how would you have wanted it to be different? (T)  
(Question 12: Piloting Stage Teacher Questionnaire)

There were no negative responses to this question. One teacher remarked that she had a different way of doing things, but that it strengthened her lessons and that she would use it even more effectively the following year.

## 5.7.5 Visual Considerations

### 1. Effectiveness of animations in visualisation of concepts.

#### Learner data:

- a) Did the use of animations (moving images) make it easier to understand some of the concepts that were being explained, or would the explanation have been just as effective without it? (Think of the moving arrows illustrating vector addition and animation of river problems showing the motion of the boat.) (L)

School	% Positive Response	% Negative Response	% Neutral Response
A (n = 47)	93.6	6.4	0.0
B (n = 8)	87.5	12.5	0.0
C (n = 17)	94.1	5.9	0.0
D (n = 19)	100.0	0.0	0.0
E (n = 24)	100.0	0.0	0.0
F (n = 36)	91.7	8.3	0.0
G (n = 58)	100.0	0.0	0.0
H (n = 58)	100.0	0.0	0.0
All (n = 267)	97.0	3.0	0.0

**Table 27: Breakdown of responses for Question 4 of Piloting Stage Learner Questionnaire**

No significant differences were found in the responses between any of the socio-economic, gender or language groups for this question.

Motivations received for this question are given in Table 28.

Positive motivations	Frequency	Negative motivations	Frequency
It was interesting / different / fun	9	Would like audio as well	1
Easier to understand	10	Need a bigger TV / projector	1
Aesthetically better	1	Computer is too slow	1
It was easy to follow – knew where it was going	1		
Learn more easily from images	1		

**Table 28: Positive and negative motivations for Question 4 of Piloting Stage Learner Questionnaire**

The very few negative responses that were received and the 97% positive response percentage show that learners really enjoy the animations. The use of animations seems to be one of the most positively received aspects of the CAIR.

- b) Do you think that the animations were effective and that they helped learners to understand some concepts more easily? Please motivate. (T) (**Question 13: Piloting Stage Teacher Questionnaire**)

All the teachers were very positive about the use of animations. Four of the teachers mentioned that they thought it made things less abstract and easier to understand. Two of them mentioned that it was especially handy because animations could be replayed.

## **2. Contribution of graphics to attractiveness of information.**

### **Learner data:**

- a) Did the images (not the animations) make the presentation more attractive or did you find the use of them unnecessary? (L)

School	% Positive Response	% Negative Response	% Neutral s
A (n = 47)	93.6	4.3	2.1
B (n = 8)	75.0	12.5	12.5
C (n = 17)	100.0	0.0	0.0
D (n = 16)	93.8	6.3	0.0
E (n = 24)	100.0	0.0	0.0
F (n = 33)	87.9	9.1	3.0
G (n = 52)	96.2	1.9	1.9
H (n = 54)	92.6	7.4	0.0
All (n = 251)	93.6	4.8	1.6

**Table 29: Breakdown of responses for Question 6 of Piloting Stage Learner Questionnaire**

No significant differences were found in the responses between any of the socio-economic, gender or language groups for this question.

Motivations received for this question are given in Table 30.

Positive motivations	Frequency
It was interesting / different / fun	1
Easier to understand	2
Aesthetically better	4
It was easy to follow – knew where it was going	1
Easier to see what was happening/not just talking	1
Structure saves time / makes teacher's job easier	1

**Table 30: Positive and negative motivations for Question 6 of Piloting Stage Learner Questionnaire**

The 93,6% positive response percentage shows that learners like images in a resource. There were no negative motivations in this question.

#### Teacher data:

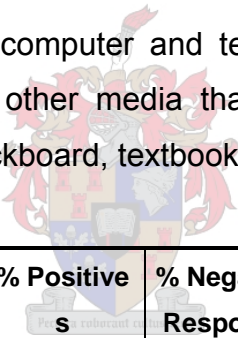
b) Did the images (not the animations) make the presentation more attractive or did you find the use of them unnecessary? (T) (**Question 14: Piloting Stage Teacher Questionnaire**)

The teachers were all positive about the images making the presentation more appealing. One specifically mentioned that it helped to keep the learners' attention and two teachers remarked that the images made it easier for them to understand certain concepts.

### 3. Appeal of user interface.

#### Learner data:

a) Did you like the use of the computer and television combination as a teaching resource more or less than other media that you have been exposed to (e.g. overhead transparencies, blackboard, textbook, etc)? Motivate your answer. (L)



School	% Positive	% Negative Response	% Neutral Response
A (n = 47)	91.5	8.5	0.0
B (n = 8)	100.0	0.0	0.0
C (n = 18)	83.3	16.7	0.0
D (n = 18)	94.4	0.0	5.6
E (n = 23)	100.0	0.0	0.0
F (n = 36)	75.0	19.4	5.6
G (n = 59)	86.4	11.9	1.7
H (n = 58)	96.6	3.4	0.0
All (n = 267)	89.9	8.6	1.5

**Table 31: Breakdown of responses for Question 2 of Piloting Stage Learner Questionnaire**

**Key:**

	Greatest financial need (Group 1)
	Middle income group (Group 2)
	Affluent areas (Group 3)



Significant differences in the responses to this question were found between Afrikaans boys and girls in socio-economic group 3  $X^2(1) = 5,1$ ;  $p = 0,024$ . The boys were found to be more positive than expected and the girls were less positive than expected. Afrikaans girls also showed a significant difference in the responses from the different socio-economic groups  $X^2(2) = 11,3$ ;  $p = 0,0016$ . Socio-economic groups one and two were more positive than expected, whereas socio-economic group three was less positive.

Motivations received for this question are given in Table 32.

Positive motivations	Frequency	Negative motivations	Frequency
It was interesting / different t/ fun	31	Hard to understand	2
It was easier to understand	29	Prefer to make own notes in class	2
Aesthetically better	9	TV was too low	1
Liked the multimedia learning/animations	9	Want resource in Afrikaans	1
Easier to see what was happening/not just talking	3	Computer is too slow	2
Saved time as there was no need to make notes	2	Teacher went too fast	1
It is easier to learn from images	1		
Structure saves time/makes teacher's job easier	2		

**Table 32: Positive and negative motivations for Question 2 of Piloting Stage Learner Questionnaire**

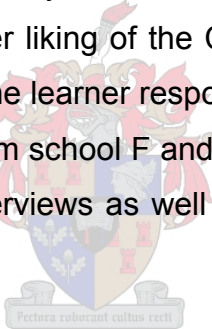
The reasons cited most often for liking the CAIR more than other resources were once again that it was easier to understand and more interesting/different/fun. The indication that 18 of them quoted multimedia learning, animations or aesthetics, relates closely to the interesting/different/fun motivation. The large number of motivations under the first two

categories may be a good indication of what to keep in mind when designing a teaching resource. Learners seem to be saying, “Make it interesting and make it easier”.

The few negative motivations that were given leaves one with the impression that, although some learners are saying that the CAIR is not better than other media that they have encountered, it is not necessarily worse.

Although there are six different negative motivations, the frequency of response for each is very low. One also needs to see the importance of setting all media up properly to benefit all learners.

Unfortunately the lack of negative motivation made it hard to pinpoint the reason for negative responses. It could have meant that some of those that answered “no” meant that the resource was not liked more or less than others. Their responses were therefore probably neutral, but this was not clearly stated. The positive response percentage of 89,9%, however, did point to a greater liking of the CAIR by the majority of learners. To clear up the uncertainty surrounding the learner responses interviews were held with them. Three learners from school A, four from school F and two from school H were interviewed. From the field notes taken during interviews as well as from recorded conversations, the following information was gathered.



### **Interview results for Question 2 of Piloting Stage learner Questionnaire**

#### **School A:**

Learner A complained that the computer was different to the textbook and that this made it hard. It went too fast on the computer. He did not use the notes that were supplied with the CAIR either as this was too similar to the computer. He preferred to learn from the textbook.

Learner B found that it was better to learn from the textbook, as she wanted to know more. However, she did use the CAIR notes to prepare for exams. These notes were used in conjunction with other notes taken down in class to study from. The textbook was only used to clear up some initial difficulties.

Learner C originally motivated his dislike by stating that the TV was not in a position where everyone could see it well. He was then asked if he would have liked the CAIR more or less if the TV was in a good position. He said that he still liked it less. He still failed to give a reason for his dislike and seemed scared or embarrassed to say why. I tried to set his mind at ease that he could speak freely. He then replied that language was an issue. He did not use the notes either as they were in English. He said that if the resource had been in Afrikaans his problem would have been solved.

It would seem that learners from school A answered this question not in terms of their classroom experience, but rather with reference to their own experiences of learning from a textbook. The three learners who were interviewed seemed quite inflexible about changing from the learning experience that they had become accustomed to. They wanted a textbook (and for learner C it had to be in Afrikaans) and seemed to find it hard to adapt to a new learning experience.

#### **School F:**

Learner A complained about the CAIR being in English. She therefore struggled to follow explanations.

Learner B simply stated that she did not like PCs and that the school's PC was also too slow.

Learner C stated that the teacher went too fast, especially where animations were shown. She also wanted repetition and the teacher did not allow enough time for this. This response shows that even though the computer may be too slow (too much needed to go to the next slide) the speed at which the teacher goes through the material depends on the teacher and not the programme.

Learner D complained again that it felt as if they were working much slower than usual. She wanted to work fast so that she could do revision at the end of term. This is contradictory to what learner C said, which indicates that a learning experience is a very personal one and that it is not always easy to suit everyone's needs.

**School H:**

Learner A stated that she preferred the old methods. She complained that things went too fast. However, she admitted that pictures and animations helped.

Learner B stated that it was hard as things went too fast and he could not copy down fast enough. It seemed though that the learner could not really recall the process that well as he had to be reminded that there were notes that made it unnecessary to copy from the PC. He then replied that the teacher simply went too fast through the work.


**Teacher data:**

- b) Does the software appeal to you visually? If not, what do you not like? (T)  
(Question 6: Training Stage Teacher Questionnaire)

The teachers all responded positively to this question. One teacher specifically mentioned that it was very clear and that there was not too much information on one page.

**4. Clarity of presentation.****Learner data:**

- a) Could you easily see what was presented on the television? If not, state what made it difficult. (L)



School	% Positive Response	% Negative Response	% Neutral Response
A (n = 47)	89.4	10.6	0.0
B (n = 8)	100.0	0.0	0.0
C (n = 20)	70.0	30.0	0.0
D (n = 18)	100.0	0.0	0.0
E (n = 24)	100.0	0.0	0.0
F (n = 35)	65.7	34.3	0.0
G (n = 58)	79.3	20.7	0.0
H (n = 56)	87.5	12.5	0.0
All (n = 266)	84.2	15.8	0.0

**Table 33: Breakdown of responses for Question 3 of Piloting Stage Learner Questionnaire**

**Key:**

	Greatest financial need (Group 1)
	Middle income group (Group 2)
	Affluent areas (Group 3)

Afrikaans boys showed a significant difference in their responses between socio-economic groups  $X^2(2) = 9,1$ ;  $p = 0,01$ . Socio-economic groups one and two were found to be more positive than expected and group three was found to be less positive. There was also a significant difference in the way that different language groups from girls in socio-economic group one responded  $X^2(2) = 6,6$ ;  $p = 0,036$ . English girls were more positive than expected and Afrikaans girls were less positive.

Motivations received for this question are given in Table 34.

Positive motivations	Frequency	Negative motivations	Frequency
It was interesting / different / fun	2	Want slides bigger	1
Easier to understand	1	Need a projector/bigger TV	18
It was easy to follow – knew where it was going	3	TV was too low	11
		Computer too slow	1

**Table 34: Positive and negative motivations for Question 3 of Piloting Stage Learner Questionnaire**

Schools F (6) and G (12) complained that they wanted a bigger TV or a projector. Schools A (5) and C (6) complained that the TV was too low. The fact that these two complaints do not feature consistently in all schools means that it is something that can possibly be addressed in setting up the TV. Teachers need to make sure that learners can view the TV from all positions in the classroom. The 84,2% positive response means that the majority of learners did not have a problem. However, it is unacceptable if some learners cannot see. Teachers need to be especially attentive to this problem.

#### **Teacher data:**

- b) Did the learners struggle to see on the television? If they did, please state what the problem was. (T) (**Question 15: Piloting Stage Teacher Questionnaire**)

Five of the teachers reported no problems. School D has an auditorium with a digital projector so the teacher responded that the question was not applicable. The teacher from school F said that the class was big and that they had problems with glare, but that it was better to have the TV than to have nothing at all. The teacher from school G said that the learners did not complain, but that it did take them a while to get used to it. She also stated that this was a surprise to her. The teacher from school H also reported problems with glare.

None of the teachers complained that the situation was so bad that it served no purpose. Instead they seemed to be happy to at least have the 74 cm TV.

### 5.7.6 Technical Considerations

#### 1. Cost effectiveness.

##### Teacher data:

- a) If you consider that you would need a PC and a TV to use this software in the classroom, would it be worth the cost to have it in your classroom? Please motivate your response. (T) (**Question 8: Piloting Stage Teacher Questionnaire**)

Only one teacher thought that it would not be worth the cost. Once again it was the substitute teacher from school C. His motivation was that learners should rather work out questions. From this motivation one could deduce that he may have misunderstood the question.

All the other teachers said that it would be worth the cost. Here are their motivations:

- It is a learning experience for both the teacher and the learner;
- It helps students to understand. One can use other programs also and learners can make presentations for lessons;
- Learners find it easier to concentrate and pay more attention to their work;
- Learners are excited and this creates interest in their work;
- Will be of great help to inexperienced teachers;
- It is a meaningful, well-structured resource that saves time and keeps learners focused;
- Teaching possibilities are expanded. Internet can also be used in the classroom in this way.

Although teachers responded positively to this question, it was felt that a better indicator would be to find out if they would still use it the following year. To test the teachers' commitment to using the CAIR three questions were asked in the Final Teacher Questionnaire. The reasoning was that I feared that some teachers might only be responding positively for fear of being judged by me as not being proactive enough. I could not be sure of psychological or emotional issues that could influence the teachers' response. In an attempt to limit responses that could be the result of teachers feeling vulnerable, the following questions were asked after teachers had already commenced teaching the following year.

### **Clarification of responses to question 8**

a) Are you going to use the resource (Computer presentations for mechanics - CAIR) again this year? If not, please state why not. **(Question 1: Final Teacher Questionnaire)**

All teachers responded affirmatively.



b) Will you be using the CAIR in a different way to last year? If so, what will you change? **(Question 2: Final Teacher Questionnaire)**

Three answered that there would be no difference. One of them added that he would have more time to prepare than the previous year. Another said that he used it in conjunction with transparencies and that this worked well.

One teacher simply stated that she would use the CAIR to introduce the concepts. The fifth teacher replied that she would use her own examples.

c) Do you find it easier to use the CAIR this year? If you are struggling, what are you struggling with? If it is easier, what has become easier? **(Question 3: Final Teacher Questionnaire)**

All the teachers responded that it was easier. A common reason was that they were more familiar with the programme and computer use. One teacher added that she incorporates the CAIR as she goes along as well as for a summary when she had finished.

From these responses it seemed that teachers showed a commitment to use the CAIR again and that it seemed to be of value. One of the teachers who teaches at a technical school where all the learners need to do Physical Science added that the CAIR was used with great success in their auditorium the previous year and that he was going to use it for Grade 12 in the following year as well.

## **2. Effectiveness of training.**

### **Researcher observation:**

- a) Confidence: The confidence with which the teacher uses the software could be an indication of the effectiveness of the training. (R)

Six of the eight teachers showed extreme confidence during the school visit. The substitute teacher from School C was not as confident, but after only a very short introduction to the system, he became quite confident.

Only one other teacher seemed a bit nervous and struggled a little with the control of animations (using the right click to bring up the quick menu). This did not cause her to deliver a bad lesson, though. She was very confident in integrating the CAIR with the rest of her lesson and moved about the classroom freely, even involving the learners in activities.

All the teachers showed an increase in confidence from the Training Stage to the Piloting Stage.

### **Teacher data:**

- b) Do you feel adequately prepared by the training to use this resource in the classroom? If not, state why not and what else needed to be done in the training session. (T) (**Question 1: Training Stage Teacher Questionnaire**)



This question was asked after the Training Stage. Six of the eight teachers simply stated that they felt well prepared. The other two added that they simply needed to practice more.

- c) Did the training prepare you adequately for use in the classroom? If not, please state why not. (T) (**Question 1: Piloting Stage Teacher Questionnaire**)

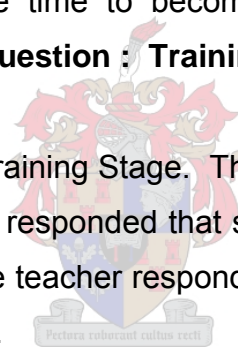
This question was asked after the Piloting Stage. Six of the eight teachers simply stated that they felt well prepared. The teacher from School C correctly reported that he had not received training. One teacher simply stated that he did not really feel that he was adequately prepared, but that he found it easy to adjust to the system.

### **3. Time needed to become comfortable with the technology.**

#### **Teacher data:**

- a) Would you need a lot more time to become comfortable with the use of this resource? If so, why? (T) (**Question : Training Stage Teacher Questionnaire**)

This question was asked after the Training Stage. Three teachers responded that they did not need much more practice. One responded that she was familiar with PowerPoint and that the CAIR was very similar. One teacher responded that the necessary practice would come by using the CAIR all the time.



One teacher felt that he needed time to integrate the CAIR with his own teaching style. Another needed time to familiarize himself with the content. The last teacher needed time for lesson planning to integrate the CAIR with other media.

It was encouraging to see that quite a few teachers acknowledged the need for proper preparation and that different aspects of preparation were identified.

- b) How long did it take for you to become comfortable with the use of the resource? What made it easy/difficult? (T) (**Question 5: Piloting Stage Teacher Questionnaire**)

This question was asked after the Piloting Stage. All the teachers reported that they became comfortable very quickly. Two of them attributed this to good training. One

mentioned that the instructions received with the programme (printed notes) made it easy. One of the most significant replies came from a teacher who wrote the following:

*Very quickly – especially bearing in mind that I am not a computer expert at all. Program is simple and seems to be pretty robust (allows for errors).*

#### **4. Technical support.**

##### **Teacher data:**

- a) Did you need technical support at any stage of using the software? What was the problem and where did you obtain support to solve the problem? (T) (**Question 7: Piloting Stage Teacher Questionnaire**)

Only two teachers had experienced problems. One had a problem finding the CAIR on her computer. She telephoned me and we sorted out her problem. The other one had a hardware problem that was sorted out by TRAC. No technical support was required for the CAIR.

During the school visit it was found, however, that one school had their screen resolution set to 640 x 480 and not 600 x 800. They therefore often had to use the scrollbars to view information that would not fit on the screen. I reset the resolution for them. Another school had their font sizes in Windows on 125% instead of 100%. This was also reset by me.

#### **5. Effectiveness of providing in-service training.**

##### **Teacher data:**

- a) Did the software help to clear up any misconceptions that you had in Mechanics to the extent that it helped you to teach more effectively? (T) (**Question 2: Piloting Stage Teacher Questionnaire**)

Three of the teachers answered that the software did help them to teach more effectively. One specifically mentioned that the CAIR contained examples that they had not thought of previously. It is important to note that these three teachers were not inexperienced. Two of the three had more than ten years experience and the third had more than five years experience.

## 6. Ease of use and ease of navigation.

### Researcher observation:

- a) Mouse skill: If teachers struggle with the use of the mouse, it could lead to them not wanting to use the PC as a resource. This is specifically monitored to compare it to the level of improvement during the Piloting Stage. (R)

Three of the teachers showed some difficulty in using the mouse during the Training Stage. Only one of them still seemed to have a slight problem during the Piloting Stage (she was mentioned above as having problems with controlling animations). This did not cause her to struggle with the CAIR. Even the substitute teacher at school C seemed to control the mouse very easily.

- b) Understanding of navigational system: The teachers' use of the first page as well as their control of flash animations is of importance. (R)

Teachers had no problems with these aspects in either the Training or the Piloting Stages.

- c) Mobility, eye contact, enthusiasm, interaction: Is the teacher so comfortable and at ease with the use of the PC that he/she is able to move away from it and not get stuck to the front of the classroom? Does the use of the equipment make the teacher interact with the equipment only and not with the class? Is there so much apprehension with the use of the equipment that the teacher projects no enthusiasm for the material at all? All of these indicate the ease of use by the teacher. (R)

All the teachers showed problems in these areas during the training session. However, one must remember that presenting a trial lesson in front of other teachers tends to make one a little more uneasy than usual. Eye contact, mobility and interaction seemed to be a problem. These problems all seemed to disappear once the teachers were back in their own classrooms. A lack of interaction was noticed at the one school, but this seemed to be more a result of them teaching in a rather large auditorium. The mobility of the teacher could also not be gauged as he was on crutches at the time owing to an injury.

### Teacher data:

- d) Do you find it easy or hard to navigate through the slides? Please say what you like or dislike or struggle with. (T) (**Question 5: Training Stage Teacher Questionnaire**)

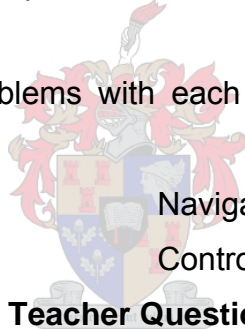
This question was asked after the Training Stage. All the teachers responded that it was easy. One specifically remarked that she liked that she could click anywhere on the screen and that information would appear.

- e) Which aspect of this resource do you find to be the most difficult or laborious? Please state why. If you have no problems with any aspect, please also state that.  
(T) **(Question 7: Training Stage Teacher Questionnaire)**

This question was asked after the Training Stage. Four teachers reported no problems. Two teachers were worried about being bound by the mouse. One worried about mobility and eye contact. One teacher worried about integration with his own teaching methodology.

These teachers all seemed to have ironed out these problems once they had been using the CAIR for a while as none of these problems were evident during the school visit.

- f) Please state if you had problems with each of the following or not and please specify the difficulty: (T)



Navigating through the slides

Controlling the animations

**(Question 6: Piloting Stage Teacher Questionnaire)**

Teachers did not report having any problems with these aspects. One teacher did complain that the slowness of his computer was a problem with navigation through the slides.

The results in this chapter have been presented with very little discussion, giving clarification only in some instances where it was needed. The discussion of how these results relate to the research questions and how they influence further development and improvement of the CAIR is presented in Chapter 6.

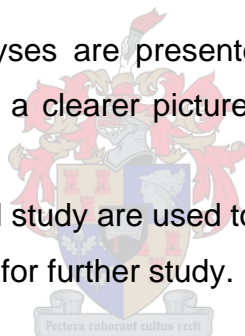
## Chapter 6

# CONCLUSIONS

### 6.1 Introduction

In the previous chapter the research results were presented without much discussion. Positive and negative aspects were reported under the relevant criteria to try and paint an objective and unbiased picture of the outcome of the study. In this chapter the results of the empirical study are discussed as follows:

1. A summary of positive and negative responses is presented to obtain a holistic view of the overall response;
2. Results from statistical analyses are presented under socio-economic, language and gender groups to obtain a clearer picture of the responses from the different groups;
3. The results from the empirical study are used to answer the research questions;
4. Recommendations are made for further study.



### 6.2 A summary of motivations

Results of the Piloting Stage investigation have been presented in Chapter 5 in categories according to didactical, visual and technical criteria. A summary of positive and negative motivations is given below. This is broken up into two categories, namely (a) responses from teachers and (b) responses from learners. There are two reasons for doing this:

1. It presents results of the investigation in a different format that helps to form a big picture of positive and negative responses;
2. Learners and teachers were asked to make any additional remarks. These have not been accounted for in the analysis given in Chapter 5, as these are open-ended response questions that do not address any specific criterion.

### 6.2.1 Additional remarks from teachers after Training Stage

- The programme is a challenge for the teacher to improve in lessons. Teachers will improve, as it requires pre-viewing and preparation.
- Inspiring.
- Good resource for in-service training of teachers. (This response by two teachers.)
- The resource would be a great help in under-resourced schools as learners can now see animated examples.
- Excellent revision tool and time-saving resource.

### 6.2.2 Additional remarks from teachers after Piloting Stage

- A positive attempt to help Science in South Africa.
- This could help to change the negative attitude towards schoolwork and education.
- Enjoyed using this software.
- If I had this resource when I first started teaching, I would have been a much more effective teacher.
- The CAIR is a valuable resource.
- Afrikaans please.

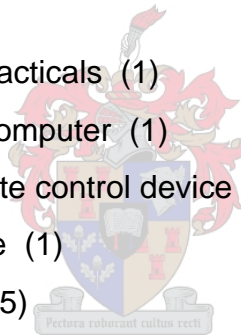
### 6.2.3 All positive motivations received from learners (Numbers in brackets indicate the frequency of motivation.)

- It was interesting/different/fun (154)
- It was easier to understand (190)
- It was aesthetically better (35)
- It was easy to follow (straight forward) – knew where it was going - starts easily and progresses – better organised (45)
- Easy to see/not just talking (22)
- Liked the multimedia learning/animations (29)
- Did not need to make own notes in class/saved time (8)
- Helps to discuss in groups (38)
- It is easier to learn from images (6)
- Studied from notes only (16)
- Disliked nothing in the TRAC system (86)
- Want chemistry also (19)
- Structure saves time/makes teacher's job easier (23)

- Introduce it to all schools (1)

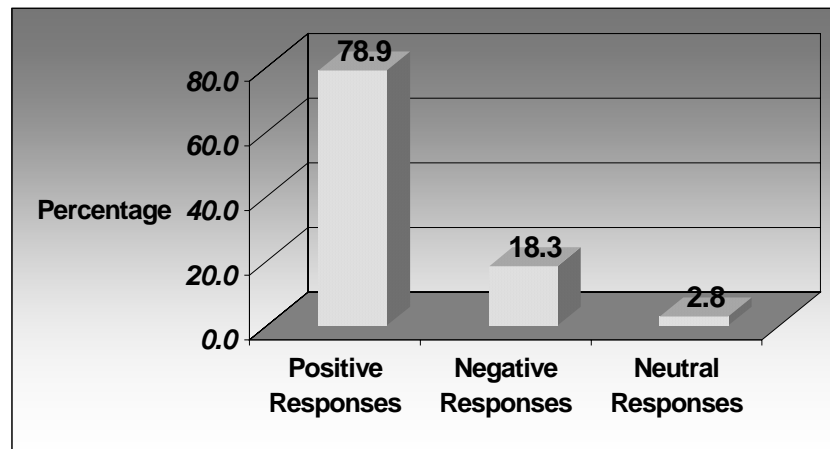
**6.2.4 All negative motivations received from learners** (Numbers in brackets indicate the frequency of motivation.)

- Want slides bigger (43)
- Harder to work in groups (2)
- More examples wanted (2)
- Hard to understand (16)
- Notes are impersonal (1)
- Prefer to make own notes in class (16)
- Would like audio also (9)
- Want a projector/bigger TV (32)
- TV was too low (15)
- Want more practicals (3)
- Dull and boring (1)
- Not enough time for practicals (1)
- Need more than one computer (1)
- Teacher needs a remote control device (1)
- Want software at home (1)
- Want it in Afrikaans (25)
- Want more colour (1)
- Computer too slow (22)
- Teacher went too fast (7)
- More slides per page to save pages (11)



## 6.2.5 A summary of frequency of positive, negative and neutral responses

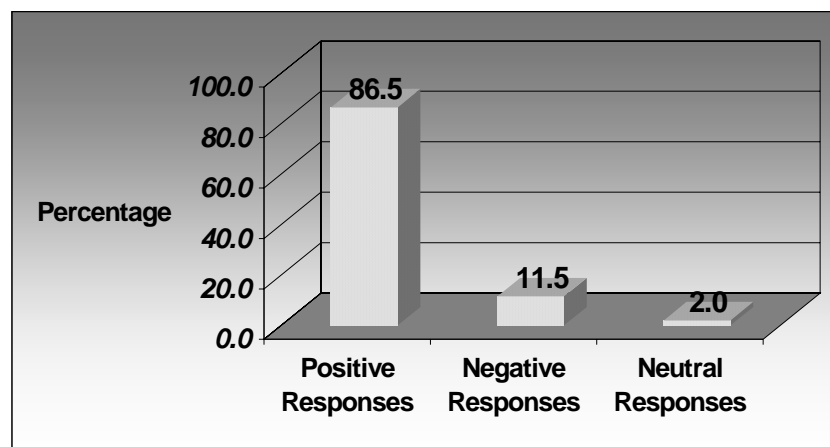
### 1. Prototyping Stage



**Figure 20: Graphical representation of learner responses for the Prototyping Stage**

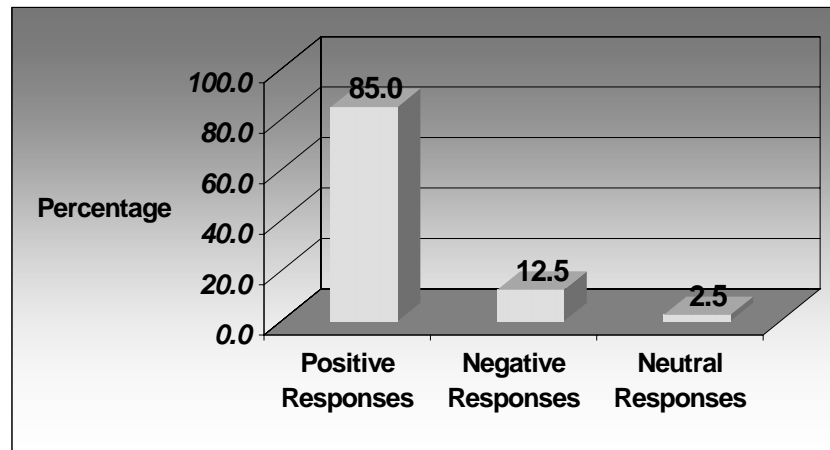
### 2. Training and Piloting Stages

In this section, each chart represents the total picture for all questions in the specific section. Charts are given for the total response given by all learners and after that for each of the didactical, visual and technical considerations. A chart is also given to show the response from both learners and teachers regarding all questions concerning the practical TRAC system.

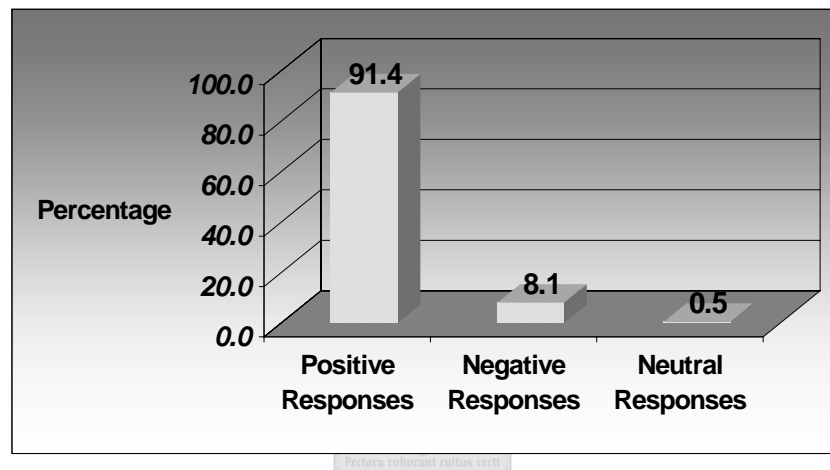


**Figure 21: Responses from learners and teachers for all criteria during Piloting and Training Stages**

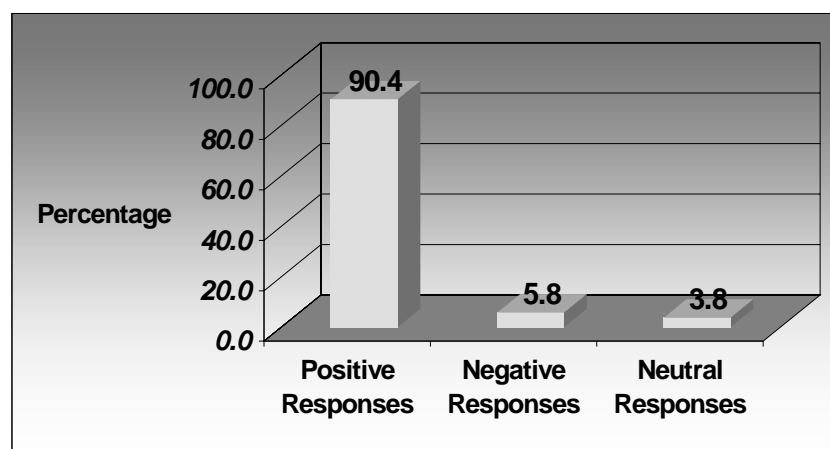




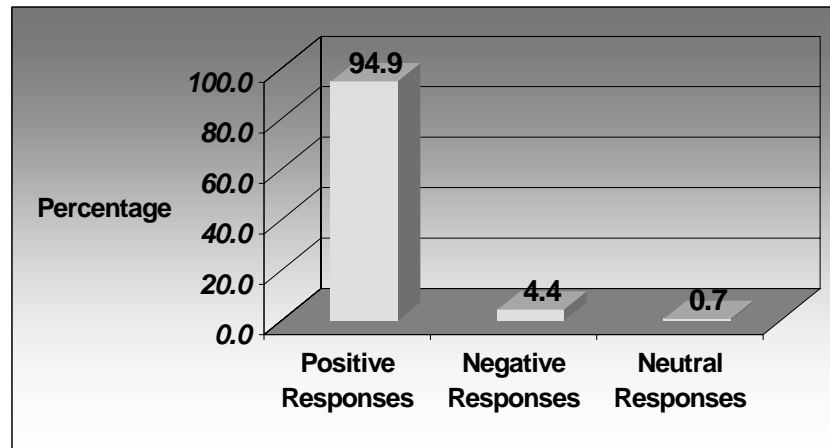
**Figure 22: Responses from learners and teachers for didactical criteria during Piloting and Training Stages**



**Figure 23: Responses from learners and teachers for visual criteria during Piloting and Training Stages**



**Figure 24: Responses from learners and teachers for technical criteria during Piloting and Training Stages**



**Figure 25: Responses from learners and teachers for questions regarding the TRAC system**

### **6.3 A summary of data produced by statistical analysis of responses of gender, language and socio-economic groups.**

The data that were produced by the statistical analysis have already been presented under the relevant criteria in Chapter 5. In this section these data are reorganised under the different groups to give a clearer picture of how the different groups responded.



#### **6.3.1 Socio-economic groups**

Afrikaans girls showed significant differences in their responses between socio-economic groups more often than any other group. Differences between socio-economic groups for Afrikaans girls appeared in eight separate analyses. They showed significant differences in responses to the following criteria:

- Bootstrap analysis indicated that socio-economic group two was more positive than group three for all criteria, all didactical criteria and all visual criteria;
- Chi-square tests showed that groups one and two were more positive than expected and group three was less positive than expected for didactical criteria 1a, 2b, 3a and 6a and for visual criterion 3a (see p. 90 for description of specific criteria). This means that socio-economic groups one and two were more positive than group three about how they were prepared, the entertainment value, the

structuring of lessons, the ease of use of the notes and the appeal of the medium compared to other media.

Chi-square tests also showed significant differences in responses between socio-economic groups for Afrikaans boys. Differences between socio-economic groups for Afrikaans boys appeared in three separate analyses. As with Afrikaans girls, they showed groups one and two to be more positive than expected and group three to be less positive than expected for didactical criteria 3a and 6b and for visual criterion 4a.

This means that socio-economic groups one and two were more positive than group three about the structuring of lessons, the use of blank pages in notes and the visibility of the CAIR on the TV.

English girls and English boys each showed significant differences between socio-economic groups only once. For the girls analysis showed that groups one and two were more positive than expected and group three less positive than expected for didactical criterion 6a (ease of use of the notes) only. Analysis also showed that for English boys, group one was more positive than group two for all criteria.

### **6.3.2 Language groups**

Analysis of responses from girls in socio-economic group three, showed that English speakers were more positive than expected and Afrikaans speakers were less positive than expected for didactical criterion 6a (ease of use of notes). Results were found to be the exact opposite for criterion 6b (use of blank pages), where Afrikaans speakers were now more positive than expected and English speakers were more negative.

English girls from socio-economic group one were found to be more positive than expected and Afrikaans speakers were found to be less positive than expected for visual criterion 4a (visibility on the TV).

English boys from socio-economic group 2 were found to be more positive than expected and Afrikaans speakers were found to be less positive than expected for didactical criterion 3a (structuring of the lesson).

### 6.3.3 Gender groups

English girls from socio-economic group two were found to be more positive than English boys from the same group when analysing responses for all criteria as well as for all didactical criteria.

Afrikaans boys from socio-economic group three were found to be more positive than expected and girls were found to be less positive than expected for visual criterion 3a (appeal of the medium compared to other media).

These results are discussed further in section 6.6 where recommendations for further study are made.

## 6.4 Answering the research questions

Four research questions were formulated in Chapter 1 (see p. 29). The first question focused on the principles that needed to be considered in software development. These principles were researched and reported in Chapters 3 and used as guidelines in the design of the CAIR.

The second question related to technical issues concerning software development. The specific focus was on developing a web-ready resource that functioned as a presentation package. I faced a number of technical challenges that are reported in Chapter 4. The solving of technical problems and the subsequent development of the CAIR is an outcome of this study that has opened up new opportunities for education that reach beyond science teaching. The same format can now be used to develop CAIRs in various subject areas, thereby creating resources that could help many teachers. If the Internet is used as a vehicle, it could contribute positively to deliver information and resources to teachers.

The third question asked how the CAIR and TRAC applications were received by teachers and learners. Empirical results for this investigation are reported in Chapter 5 and a summary has been given in section 6.2. The general response has been overwhelmingly positive for both the CAIR and TRAC. This outcome opens the door to develop the CAIR for all topics in Physical Science and to bring research results to the attention of all relevant role players. Responses received from teachers and learners led to some changes being implemented along the way and presented us with guidelines as to aspects that still need changing. In section 6.5 the changes that were made as well as the effect

that responses could have on any further development of the CAIR are discussed. Section 6.5 also includes a discussion on the integration of TRAC into lessons.

The fourth question addressed the issue of the CAIR assisting teachers in structuring lessons. The discussion in section 6.6 reflects how this study shows that a CAIR can play a positive role in structuring lessons.

## **6.5 Issues relating to the third research question**

### **6.5.1 Changes made after the Prototyping Stage**

The 78,9% positive response frequency indicates that the majority of the learners in the Prototyping Stage were positive about the CAIR. Under visual considerations the only negative responses were that one learner did not like the black background and that two of them wanted a bigger TV or a digital projector.

The black backgrounds are necessary to reduce flicker and, although a bigger TV or digital projector would be helpful to have, it is clearly not a necessity as learners could see well enough on the 74 cm TV.

More negative responses were received concerning didactical considerations. As can be seen in the previous chapter, most of these responses had a very low frequency. The following issues deserve some discussion.

- Learners complained about the black background in the notes. This was anticipated and as reported in Chapter 4 (see section 4.7, p. 81) the background was later changed. However, this was too late for the Prototyping Stage as notes had already been printed. This problem had therefore been attended to and the printable format was changed for the Piloting Stage.
- There were eight negative responses that stated it was difficult to understand. These learners also used tutorials, past papers and textbooks, but many of them still found it difficult. In retrospect I should have cleared up, with interviews, whether learners were finding the content or the resource difficult to understand. At the time of recognising a possible ambiguity in responses, the learners had already graduated and left. The fact that these learners received their full syllabus by

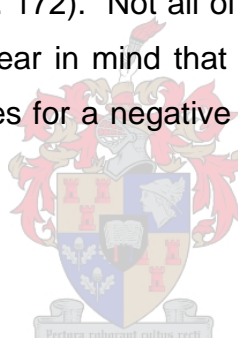
computer-aided instruction and did not struggle with all the sections means that it is difficult to draw any conclusions about the role that the resource played in any difficulties they might have experienced.

- Seven of them said that they did not feel better prepared. It is uncertain whether this meant that they perceived the preparation to be worse or the same as with other methods. It would also have helped if this possible ambiguity could have been cleared up with interviews.

Besides the printable format some typing errors in the CAIR were also corrected for the Piloting Stage.

### **6.5.2 Improving the CAIR after the Piloting Stage**

In deciding how to improve the CAIR, it is necessary to look at all the negative responses. All of these have been listed (see p. 172). Not all of them need consideration as many of them have a very low frequency (bear in mind that 276 learners had 17 opportunities to give motivations – 4692 opportunities for a negative response.) Only the most significant ones will be discussed here.



#### **6.5.2.1 Responses from learners**

##### **(i) Didactical Considerations**

##### **The language issue**

The six learners (see p. 130) who remarked that they wanted the resource in Afrikaans came from school A (2) and school (F). If one looks at this response in total, though, it comes up 25 times in all the responses. Fifteen of these come from school F, nine from school A and one from school H. If one notes that of the 108 Afrikaans speakers who responded, only 25 complained about language (23,1%), it would seem that most Afrikaans speakers are comfortable with English. The language issue also came up during interviews with learners. This made me realise that, even though it is a minority complaining about the issue, these learners will sometimes not use the notes due to the language issue. The ideal would therefore be to present notes in Afrikaans as well.

##### **Teacher going too fast**

The four learners (see p. 130) who complained that the teacher went too fast, all come from school H in the written questionnaires. Learners from this school reported the same

problem again during interviews. A learner from school F also reported this problem during an interview. This was interesting seeing that this was the school that had problems with a computer that was too slow. One has to realise the real danger of moving too fast for learners, as the next bit of information is only a click away. This is something that teachers have to be aware of and it should be stressed in training sessions.

### **Size of the printed slides**

Forty three responses stated the need for bigger printed slides. Interestingly though, there were eleven responses stating that they could be smaller. It was found that some learners want bigger slides to make notes on the slide next to printed information. Seventeen of the forty-three were from school F, which had its slides reduced to six on a page. Nineteen of the forty-three were from school E, where learners received their notes back-to-back without the blank pages and therefore did not have enough space to make notes. 77,3% of learners did respond positively to three slides per page. It would therefore seem that three slides per page with blank pages would be the best solution. It is understandable that schools would try and save money by copying back-to-back. In such cases schools must not reduce slides further.

### **(ii) Visual Considerations**

#### **The need for a bigger TV**

Five of the six learners who said they needed a bigger TV (see p. 130) came from school F. However, on visiting the school, it was found that the CAIR was clearly visible even from the back. Maybe this expectation from learners can be related to the school serving a more affluent socio-economic society.

In total thirty-two learners complained that they wanted a bigger TV or projector at some or other stage in the questionnaire. The cost of digital projectors is, of course, out of reach of most under-resourced schools. Bigger TVs are also very expensive. Is there a way to improve the visibility by changing the CAIR? The answer to this is to be found in Chapter 3, where the principles for software development were researched. Choosing a bigger font would mean that there would be very little information on a slide. That means that concepts that should be treated on one slide may now be split over several slides and that the presentation could become disjointed. A better solution may therefore be to have a second TV in the classroom closer to the back. One would probably find in most cases,

though, that the TV could simply be repositioned and that it is merely a case of finding the optimum position for the TV to ensure visibility to all learners.

There was an 84,2% positive response to being able to see on the TV. The school that had the most negative response (school C) had the TV positioned too low. The visibility problem could therefore easily be solved.

### **(iii) Technical Considerations**

#### **The need for a faster computer**

Four of the five (see p. 130) learners who said the computer was too slow came from school F. On visiting the school it was found that the computer was slow on the animations. This computer was not supplied by TRAC for the study, but was the school's property and they preferred to use it.

Twenty-two responses were received about computers being too slow. This problem was mentioned by learners again during interviews. This is a very real problem that could affect animations negatively and also increase waiting times for the next slide. The method that was used to produce the CAIR (web-ready option) already solves some of the speed problems encountered with other presentation packages that are more hardware intensive. The problem is that computers need the ability to run at least fourth-generation browsers. This does mean that one cannot rely on old technology if one wants to enjoy the full potential of animations or even video in a CAIR. Schools are not necessarily a good dumping ground for old computers. We need to be willing to invest in good technology for learners to gain the full advantage of what can be offered.

If we want to aim at using the Internet also, we cannot settle for cheap old equipment any longer. Although the CAIR will run on a 486 machine with 16 meg RAM, this is not the best option. A good rule of thumb is that the computer must be able to handle the Internet and all its multi-media capabilities easily. There is unfortunately very little that can be done to make the CAIR any faster. Images have already been compressed and the shockwave format for animations is much faster than other options as it shockwave was made for the Internet.



It is also interesting to find that School A had a slow computer during the school visit. However, only one learner remarked that the computer was too slow. Maybe this shows the huge impact that simply bringing a computer into the classroom has on some learners.

#### **6.5.2.2 Responses from teachers**

There was nothing to be found in the teachers' responses to indicate that anything needed changing. The only comment was that they would want the CAIR in Afrikaans. This issue has already been discussed (see p. 179). Teachers were very positive. The only exception was the teacher from School C, who had not received training.

This teacher was negative about a number of aspects, as reported in Chapter 5. This emphasises the importance of initial training. Such training would probably be a once-off session for most teachers as there was no technical support needed for the CAIR. Support was needed by two people for hardware and operating system-related problems. Teachers also need to seek assistance if needed. The substitute teacher from school C never called for help, even though he was contacted by me a number of times during the Piloting Stage. It could therefore be that teachers may choose not to use the CAIR owing either to personal preferences or technophobia.

Judging from the responses by teachers and learners there is nothing in the CAIR itself that warrants changing. I felt that the CAIR needed more examples, but it was clear from the teachers' response that they preferred to supply learners with their own extra examples.

#### **6.5.2.3 Responses to TRAC practicals**

When one reviews the responses on the TRAC practicals, it becomes clear that teachers and learners are positive about the use of the TRAC system. One has to bear in mind that the availability of only one computer makes it very hard for teachers to structure practicals to involve all learners. A shortcoming of this study is that it did not determine the extent to which TRAC practicals were covered in the classroom. At the time of learners completing questionnaires, two schools had not yet covered any of the practicals. Only two of the eight schools (see p. 144) indicated that they integrated TRAC practicals with the CAIR. Although many learners clearly had some exposure to TRAC practicals (they responded to questions referring to their experiences with TRAC), the frequency and extent of their exposure to the TRAC system is unknown. I am concerned that equipment constraints

could lead to the TRAC system being under-utilised. Seeing that the majority of the schools indicated that they do not integrate practicals with the teaching of theory, it could mean that time constraints could lead to practicals not being done at all.

The primary question here is how to involve everybody. The answer may lie with group work, as learners were mostly positive about group work. The problem here is that all learners may still not get to do all practicals. At the school where I teach, learners get to do only one of the Mechanics practicals as time is limited. Learners work in groups, but each individual is required to write a report. A class presentation is expected from the group. This makes it possible to assess a number of skills while giving everyone the chance to do at least one practical. Nonetheless, all the learners get to see all the practicals. The groups presenting the practicals also have to involve the class in some way and need to prepare handouts for the class on the practicals. This is by no means an ideal situation. It would be much more effective to have a software solution (a virtual-laboratory) that integrates both the CAIR and the TRAC practicals. This would save on the cost of the hardware required for TRAC and would make it possible to have the software handy in the classroom as well as on the schools' network. All the learners could then do all practicals. Problems like friction could be eliminated. This could also mean that learners could do practicals in their own time after school. This would save time in terms of setting up and practicals could be redone very easily. A possible disadvantage is that the learning experience becomes removed from reality as they are working in a simulated environment only.

Constructivism and the conceptual change model (Posner and Gertzog 1982: 214) have made us aware that it is very hard for learners to replace existing unacceptable concepts with more scientifically acceptable ones. This is perhaps why tutorial programmes on computers are not always successful. It is a difficult and involved process to change those concepts. Although the TRAC practicals make it possible for learners to experience some of the theory in a more hands-on approach, these practicals alone cannot be expected to rectify what went wrong in the classroom.

#### **6.5.2.4 My own experience**

I found that there were a few spelling errors that needed correcting as well as some printing problems. Some of the images with fill (colour) in them and text within the fill,

came out too dark so that the text could not be read. These were changed to make the text readable.

My experience of using the CAIR has also brought to light that it may be better not to compile the html files. Two considerations form the basis for proposing this. Firstly, none of the computers in the Pilot Stage were running Windows XP. When I received a computer upgrade at my school, the new machine was supplied with Windows XP. I subsequently found that the compiled version sometimes failed to execute. For fear of some of the files being deleted or moved by other users that were not as computer literate, I decided to have all the files for each individual topic in its own folder, identified by its topic (e.g. Momentum). All the files in the folder were then hidden except for the first navigation slide which is needed to execute the slide show. Any teacher using the programme would therefore only find the one file in the folder. This would prevent accidental moving or deletion of files.

The second reason for doing this is to be found in my support of the principles of open content development. Some teachers using the CAIR may be more computer literate than others. These teachers may want to add their own examples and slides, or may want to change some things within the CAIR. These teachers will then just need to remove the hidden attribute assigned to the other files to make them visible and accessible for editing. This will hopefully be a positive step in the direction of open content development, where teachers have the right not only to contribute new CAIRs, but also to change existing ones.

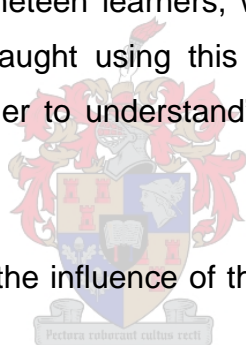
## **6.6 The CAIR as a resource to help structure lessons**

In Chapter 2 (see p. 34) it was reported that the empirical investigation had to focus on ease of use, teacher attitudes towards software, empowerment of teachers to become more effective, learner attitudes towards the software, technical difficulties and edutainment value. Some of these issues will be addressed in the next section, which explores how the CAIR needs to be improved. In this section an attempt is made to discuss the results from the Piloting Stage investigation in terms of the feasibility of the CAIR as a resource that could help under-qualified or inexperienced teachers. This section will focus on responses from the learners and the teachers.

### 6.6.1 Responses from learners

76,1% of the learners responded that they felt the lessons were more structured. This means that they perceived that the teachers were teaching better. Except for the teacher from school H (who had more than 5 years experience), all the other teachers had more than 10 years teaching experience. In four of the schools the positive response percentages were 92,6%, 93,3%, 93,5% and 100%. These very high percentages indicate that learners experience the CAIR as having a very positive effect on the structure of lessons.

One should also note that twenty-three learners from the eight schools chose to state in a motivation that the structure saved time and made the teacher's job easier. This is significant as the motivation is something that the learner formulates and is not given by the questionnaire. Forty-five learners used the following motivation at some or other time: It was easy to follow (straightforward) – knew where it was going - starts easily and progresses – better organised. Nineteen learners, when asked for any extra response, said that they wanted Chemistry taught using this method as well. Maybe the most profound indicator is that "it is easier to understand" was a response that featured 190 times.



The negative responses relating to the influence of the CAIR in structuring the lesson are discussed below.

"It is hard to understand" was reported sixteen times. "The teacher went too fast" was reported seven times. These negative responses serve to remind us that a resource is very seldom a perfect solution for everyone. The teacher still needs to monitor who is not being served well by the resource and needs to test and assess the understanding of the learners. It also important to remember that resources should not determine the speed at which one teaches. The teacher needs to control pace according to the ability and performance of the learners. The resource must be a tool to be used and the teacher needs to remain in control. This is an aspect that lies within the control of the teacher and is not determined by the resource.

The interview results on p. 131 also focus our attention on another issue. Although I saw it as a positive point when teachers could incorporate the CAIR with other media and resources in the lesson, some learners saw this as negative. Some learners from school F

reported that the teacher jumped around too much and that this affected the structure of the lesson negatively, making it disjointed. This reminds us again that teachers need to know the preferences of their learners and that it is hard to draw conclusions that are generally true for everybody.

### 6.6.2 Responses from teachers

As already remarked in Chapter 5, the response from teachers about the influence that the CAIR has on structuring the lesson was very positive. It either helped them, or they were able to adapt to use it effectively. It was also interesting to see that quite a few teachers referred to the positive influence that the CAIR has on the structure of the lesson in their additional remarks. Statements like: *The programme is a challenge for the teacher to improve in lessons. Teachers will improve, as it requires pre-viewing and preparation; Good resource for in-service training of teachers; The resource would be a great help in under-resourced schools as learners can now see animated examples; Excellent revision tool and time-saving resource, and If I had this resource when I first started teaching, I would have been a much more effective teacher* all point to the positive influence the CAIR has on the structure of a lesson.

One teacher who reported after the Training Stage that he was worried about integrating the CAIR with his own teaching methodology (see p. 166), reported after the Piloting Stage that he did not have problems integrating the CAIR and that the CAIR helped to structure the lesson.

From the responses from both learners and teachers it would seem that there is a very positive feeling that the CAIR can play a significant role in structuring lessons.

This study has shown an overwhelmingly positive acceptance of the CAIR by both learners and teachers. If this resource can now be integrated with a set of virtual practicals (like a software solution of TRAC) it may be able to contribute even more significantly to the structure of lessons.

It can probably be considered as a short-sighted approach to supply computers to schools and link them up in networks if software that could use the hardware is not supplied. When visiting one of the schools the principal showed me computers that had been given to the school as a prize that had been won. These computers were unfortunately not

functioning, as the school was receiving neither support for the network nor software to be used on it. I want to appeal to the common sense and reason of all relevant role-players to refrain from spending money on solutions that become mere token gestures in schools. Our efforts may be more rewarding if we refocus our attention on the classroom and on what can be accomplished by spending more money where it will be used on a daily basis.

It is therefore suggested that time and money should be put into the development of CAIRs and virtual practicals that can be used in both classrooms and on network facilities.

## **6.7 Recommendations for further study and action**

Although the solution offered here is one that makes use of a web-ready format for CAIRs, it would be short-sighted to suggest that solutions should always use this format. As long as the software that is developed can easily be downloaded off the Internet and does not require costly programmes to be installed to view the software, other formats should be investigated. A further criterion to bear in mind is that changes should be able to be made quickly and easily without incurring massive costs for each new release. One possible solution that seems promising is to investigate the use of Powerconverter (the first release was on 24 July 2002) to convert PowerPoint files to much smaller Macromedia Flash files without loss of animation effects. If this application works well, one could easily produce CAIRs by using PowerPoint and then simply convert them to Flash files. As it is probably easier for most people to make PowerPoint files than web pages, it means that this application can also open the door to investigating open content development as a way to develop CAIRs.

If it is found that there is no institution, NGO or government sector that could deal with the demands of developing software, then text book publishers should be allowed an opportunity to assist in the developing process. This solution would need some investigation into the possibility of advising teachers on which products would be suitable for use in the classroom.

The study has indicated that the CAIR could assist teachers in structuring lessons. A separate study could investigate how successful the CAIR is in introducing new teaching strategies into the classroom. It would probably be advisable to use the same schools and to present them with an alternative to teaching, for instance, certain aspects of Newton's



Laws. In this way the only new variable that is being investigated would be the different strategy as these schools have already communicated their attitudes towards using the CAIR. It was not possible to include such an investigation in this study as the same time as investigating how the CAIR was received. It would then have been very difficult to identify whether negative attitudes could be attributed to the CAIR or the new strategy.

The most significant differences in responses were found between socio-economic groups for Afrikaans girls and boys. Learners from more affluent areas seemed to be less positive than learners from less affluent areas. One may reason that this is because of the novelty factor in the less affluent areas. A few aspects in this study attempted to diminish the novelty factor. All pilot schools were TRAC schools. The use of computers was therefore not novel. Questionnaires were also completed six months after teachers had started using the CAIR. Interviews were held twelve months after teachers started using the CAIR. This raises questions as to why these differences are found, but also more specifically why these differences between socio-economic groups are more apparent for Afrikaans girls and boys. An independent study would probably do well to focus specifically on this issue.

Gender and language did not seem to play a large role in learner responses as significant differences in responses were only found in a few cases. Section 6.3.2 (see p. 176) showed that English speakers were more positive than Afrikaans speakers on certain issues. The fact that these differences occurred in so few cases raises questions about the effect of non-mother-tongue resources on learner attitudes. This study seems to suggest that language does not play a large role in the way that the CAIR was received. This could mean that learners have become accustomed to receiving many resources in English and that this therefore does not influence their attitudes negatively. A separate study is needed to focus specifically on learner attitudes towards the use of resources that are not in their mother tongue. For a country like South Africa, with eleven official languages, this could be very meaningful in shedding light on the role that language preference should play in the development of future resources.

As was reported in Chapter 1 (see p. 28), some literature has shown that one could expect a more positive response from boys than girls. This study found that the gender difference was not very significant in student responses and that English girls were in fact more positive than their male counterparts on all criteria and all didactical criteria. This could

mean that the introduction of CAIRs into the classroom could be the way to introduce girls to computers in a way that would not leave them more negative than the boys towards computers. This question can be answered by doing a study where girls from an experimental group are introduced to computers in the classroom via a CAIR first and thereafter introduced to TRAC. The control group would be introduced to computers in the classroom by going straight into TRAC tutorials without exposure to a CAIR. The study could then compare the attitudes between the two groups to determine if this more gradual approach to introducing computers helps to overcome some of the more negative attitudes (as reported in literature) that girls have towards computers compared to the more positive attitudes of boys.

A final recommendation for further study involves the TRAC system. This study did not focus on the extent to which the TRAC system is used by the project schools. Currently, TRAC requires of schools to complete reports on the implementation of the TRAC system. Schools stand to lose TRAC equipment if they do not utilise the resource. This means that their reports may not be totally representative of actual usage. Only two of the eight project schools indicated that the TRAC system is integrated with teaching. The rest prefer to do practicals afterwards. This can be understood owing to the limitation that working with only one computer has on doing practicals. However, this also means that it is easy to neglect doing practicals. To assess the true impact of this limitation on usage, it is recommended that a study be undertaken that tests the usage of the TRAC system. This could involve assessing learner knowledge of practicals after schools claim to have completed them.

Every effort should be made to make educational authorities aware of the possibilities that development of CAIRs offer. Partnerships with curriculum developers should be sought to ensure the timeous development of CAIRs that reflect the guidelines of the new curriculum.

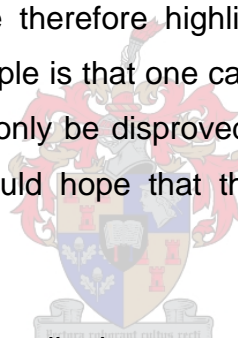
Partnerships should also be sought with institutions that could offer funding for the development and implementation of CAIRs in schools. This should address both the cost of supplying hardware and the development of the software.



## 6.8 A final reflection on the study

Before reporting on how this study has contributed to our knowledge and attempts to alleviate some of the problems surrounding Science education in South Africa, I wish to emphasise the following important aspect of this study.

Throughout the developmental process, evaluation focused on the negative issues. A special effort was made to bring all the negatives (no matter how small the frequency of response) to the reader's attention. There were two reasons for doing this. Firstly, the developmental process made it necessary to identify the aspects that needed changing and improvement. By indicating the negative motivations as well as their response frequencies, one could identify the negative aspects as well as their severity. The second reason was that the theoretical framework had focused on my assumption that it was worthwhile pursuing the development of the CAIR. This may leave the reader with the suspicion that I had an expectation that the CAIR would work and was therefore biased in my interpretation. Negatives were therefore highlighted to try and steer clear of this possible bias. The underlying principle is that one cannot prove an assumption by quoting examples of where it works; it can only be disproved by falsification methods focused on where the assumption fails. I would hope that this approach has contributed to the reliability of the research.



This study has made the following contributions:

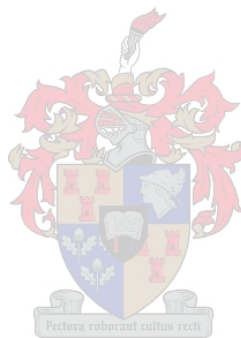
1. The study has provided a theoretical framework that refocuses our attention away from the more traditional approach of measuring learning outcomes by evaluating success or failure of interventions towards an approach that looks at measuring the way in which an intervention is received by teachers and learners. The discussion surrounding this framework has referred to both experience-based and literature-based theory to support the assumptions (see p. 2).
2. As shown in Chapter 1 (see p. 3) we are faced with the problem of vast numbers of under-qualified and inexperienced Science teachers. Grayson has suggested (see p. 4) that we need to do something else?, while embarking on the lengthy process of training and re-training teachers. This study has developed and tested an intervention that can be used as a vehicle to bring content to the classroom in a format that can be used directly by teachers. This vehicle makes use of the Internet

as a communication highway to deliver the resource. The study has shown an overwhelmingly positive response to the CAIR from both teachers and learners.

My experience has shown the use of CAIRs to be successful beyond the Science classroom. The Art department at the school where I teach had to introduce an animated theatre project to Grade 8 learners as part of a Design and Technology course. Examples of animated theatres could be found all over the Internet, but logistical problems with having five Grade 8 classes gaining access to the Internet timeously to introduce the project made it impossible to use the computer laboratory for the introduction. I made a compilation of the different examples in a single CAIR that the Art teachers then used as a resource in the classrooms (which are equipped with PCs connected to TVs) to introduce the project. This brought the Internet to the classroom, without having Internet access in the classroom.

3. The study has provided a set of criteria based on suggestions from the literature that can be used to assess multimedia presentation solutions. It has also produced a multimedia solution against which to measure other solutions (a sort of benchmark).
4. Furthermore, it has served to refocus the attention of role players in projects like the Khanya project to solutions other than providing networks to schools. It also warns against pitfalls of network solutions by referring to studies like the ACOT study and the work of researchers like Reeves and Kleiman (see p. 13). Implementation of the CAIR offered a low-cost solution whereby thirty science classrooms could be equipped at the cost of one computer laboratory in one school. In this way it has succeeded in bringing technology into the Science classroom so that teachers can start the long process (according to the ACOT study) of becoming efficient and innovative computer users. The intervention requires very little computer literacy from teachers and eliminates some of the problems noted in other studies that arise from blindly introducing technology without a clear educational goal.
5. Finally, the study has opened a door for TRAC to develop and integrate CAIRs with their virtual laboratories. These resources can be presented to the Western Cape Education Department as possible solutions to some of the problems surrounding the acquisition of software tailor made for South African schools.

I hope that TRAC will see the results of this study as an incentive to spearhead the development of software solutions that make use of Internet technology for delivery. At the same time I suggest that TRAC can become a driving force and manager of open content development to inspire and empower teachers to contribute to the development of software solutions.



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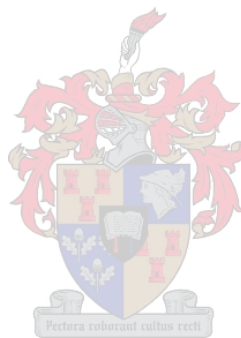
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## Addenda

This section contains the addenda for the study. They are presented as follows:

- Prototype and Piloting Stage learner questionnaires
- Training Stage teacher questionnaire
- Piloting Stage teacher questionnaire
- Final teacher questionnaire
- Training material
- Examples of TRAC practical sheets
- CAIR



## Prototype and Piloting Stage learner questionnaire

Questionnaire number:

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### Personal Information

1. School: \_\_\_\_\_
2. Grade: \_\_\_\_\_
3. Name and Surname: \_\_\_\_\_

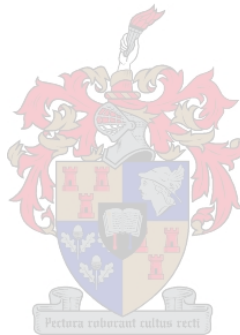
Please circle the number or letter of correct choice

#### 4. Sex

Male	1
Female	2

#### 5. Home Language

English	1
Afrikaans	2
Other	3



#### 6. On which grade do you take Physical Science?

HG	1
SG	2

#### 7. Which symbol did you obtain for Physical Science in your last exam?

A	B	C	D	E	Lower than E	No Exam taken
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**This questionnaire forms part of a research study. Please answer the questions honestly. Please give motivations wherever they are required.**

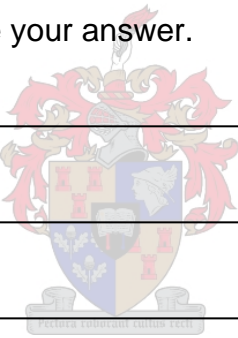
1. **D2:** Did you like or dislike the computer based presentation method? Motivate your answer.

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2. **D2, V3:** Did you like the use of the computer and television combination as a teaching resource more or less than other media that you have been exposed to (e.g. overhead transparencies, blackboard, textbook etc)? Motivate your answer.



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3. **V4:** Could you easily see what was presented on the television? If not, state what made it difficult.

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4. **V1:** Did the use of animations (moving images) make it easier to understand some of the concepts that were being explained, or would the explanation have been just as effective without it? (Think of the moving arrows illustrating vector addition and animation of river problems showing the motion of the boat.)

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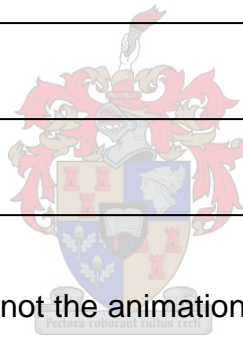
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5. **D2:** Did you find this method more entertaining than other teaching methods that you have encountered? Motivate your answer.

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6. **V2:** Did the images (not the animations) make the presentation more attractive or did you find the use of them unnecessary?

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7. **D3:** Do you think the lesson was more structured (better organised) than others that you have experienced before? Please say why it was or why it was not.

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8. **D6:** Did you find the notes easy or difficult to study from? Please motivate your answer.

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9. **D6:** Did you use the blank pages next to the slides to take extra notes/examples off the board?

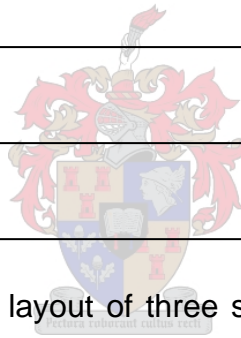
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10. **D6:** What, except the notes, did you use to study from in preparation for tests and exams?

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11. **D6:** Did you like the layout of three slides per page in the notes or would you have preferred it to be different? How would you have changed it?

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12. **D1:** Do you feel that you are being prepared better through the use of this method or not? Motivate your response.

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13. **D5:** Did the use of the TRAC system for practicals help you to better understand the concepts in those practicals?

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14. **D5:** Did you like or dislike the format of the practical sheets that you had to complete? If you choose dislike, please say how you would improve it.

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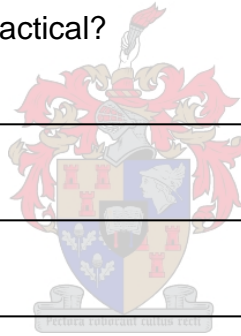
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15. **D5:** Did you work in groups and did that make it harder for you to gain benefit from the practical?

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16. **D5:** What did you dislike about the TRAC system?

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17. **General:** Any other remarks?

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## Training Stage teacher questionnaire

Questionnaire number:

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### Personal Information

1. School: \_\_\_\_\_
2. Name and Surname: \_\_\_\_\_

**Please circle the number or letter of correct choice**

### 3. Sex

Male	1
Female	2

### 4. Home Language

English	1
Afrikaans	2
Other	3



### 4. How many years have you been teaching Science?

<5	1
5-10	2
>10	3

**This questionnaire forms part of a research study. Please answer the questions honestly. Please give motivations wherever they are required.**

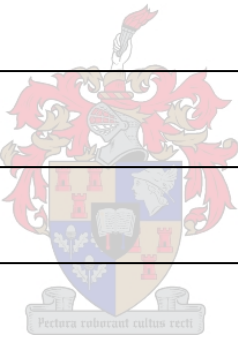
1. **T2:** Do you feel adequately prepared by the training to use this resource in the classroom? If not, state why not and what else needed to be done in the training session.

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2. **D4:** Do you think that this resource could help save you time in the classroom? If so, in what sense?



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3. **D3:** Do you think this resource could help you in structuring your lesson?

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4. **T3:** Would you need much more time to become comfortable with the use of this resource? If so, why?

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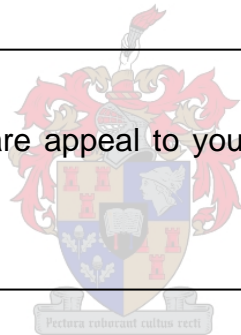
5. **T6:** Do you find it easy or difficult to navigate through the slides? Please say what you like or dislike or struggle with.

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6. **V3:** Does the software appeal to you visually? If not, what do you not like?



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7. **T6:** Which aspect of using this resource do you find to be the most difficult or laborious? Please state why. If you have no problems with any aspect also please state that.

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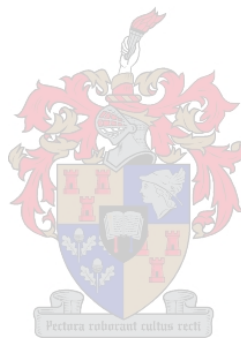
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8. **General:** Any other remarks?

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## Piloting Stage teacher questionnaire

Questionnaire number:

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### Personal Information

1. School: \_\_\_\_\_
2. Name and Surname: \_\_\_\_\_

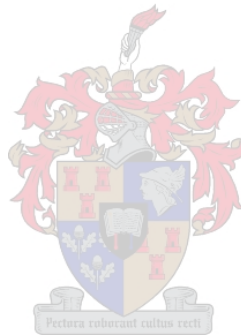
Please circle the number or letter of correct choice

### 3. Sex

Male	1
Female	2

### 4. Home Language

English	1
Afrikaans	2
Other	3



### 5. How many years have you been teaching Science?

<5	1
5-10	2
>10	3

### 6. In which grade(s) did you use the CAIR?

10	1
11	2
12	3



**This questionnaire forms part of a research study. Please answer the questions honestly. Please give motivations wherever they are required.**

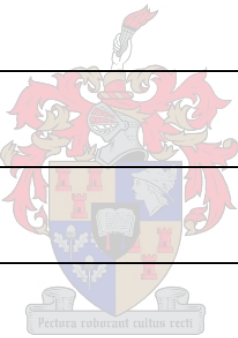
1. **T2:** Did the training prepare you adequately for use in the classroom? If not, please state why not.

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2. **T5:** Did the software help to clear up any misconceptions that you had in mechanics to the extent that it helped you to teach it more effectively?



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3. **D4:** Did the use of the software help save you time in the classroom? If so, Why?

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4. **D3:** Did the software help you to structure your lessons?

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5. **T3:** How long did it take you to become comfortable with the use of the resource? What made it easy/difficult?

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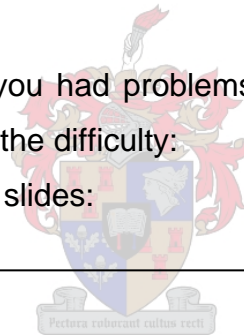
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6. **T6:** Please state if you had problems with each of the following or not and please specify the difficulty:  
Navigating through the slides:

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Controlling the animations:

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7. **T4:** Did you need technical support at any stage of using the software? What was the problem and where did you obtain support to solve the problem?

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8. **T1:** If you consider that you would need a PC and a TV to use this software in the classroom, would it be worth the cost to have it in your classroom? Please motivate your response.

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9. **D1, D7:** Did you find the content to be correct, comprehensive and relevant to the curriculum? If not, please indicate the shortfalls.

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10. **D7:** Were there enough, too few or too many examples in the resource?

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11. **D8:** Did the resource allow for enough flexibility or did you feel restricted by it? Please motivate.

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12. **D9:** Did you like or dislike the way in which content was revealed and presented to the learners? If you disliked it, how would you have wanted it to be different?

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13. **V1:** Do you think that the animations were effective and that it helped learners to understand some concepts more easily? Please motivate.

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14. **V2:** Did the images (not the animations) make the information more appealing or were they unnecessary?

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15. **V4:** Did the learners struggle to see on the television? If they did, please state what the problem was.

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16. **D5:** How did you integrate the use of this resource with the TRAC system? Did you do specific practicals directly after the theory or did you leave it till later?

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17. **D5:** Did your learners perform the practicals in groups, individually or did you do a demonstration?

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18. **D5:** What did you like and dislike about the TRAC system?

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19. **General:** Any other remarks?

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## Final teacher questionnaire

Questionnaire number:

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### Personal Information

1. School: \_\_\_\_\_
2. Name and Surname: \_\_\_\_\_

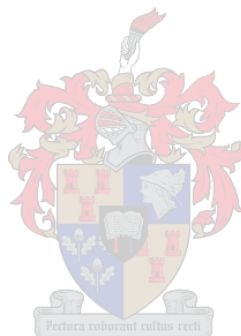
**Please circle the number or letter of correct choice**

### 3. Sex

Male	1
Female	2

### 4. Home Language

English	1
Afrikaans	2
Other	3



### 5. How many years have you been teaching Science?

<5	1
5-10	2
>10	3

### 6. In which grade(s) did you use the CAIR?

10	1
11	2
12	3

**This questionnaire forms part of a research study. Please answer the questions honestly. Please give motivations wherever it is required. The purpose of these questions is to address some matters that need clarification after the previous questionnaires were analysed.**

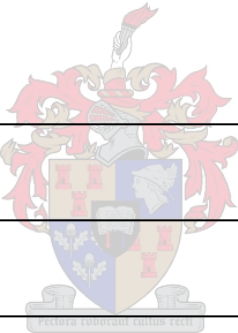
1. **Q8:** Are you going to use the resource (Computer presentations for mechanics - CAIR) again this year? If not, please state why not.

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2. **Q8:** Will you be using the CAIR in a different way to last year? If so, what will you change?



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3. **Q8:** Do you find it easier to use the CAIR this year? If you are struggling, what are you struggling with? If it is easier, what has become easier?

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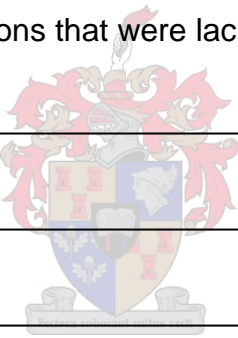
4. **Q9:** Did you need to use other resources except the CAIR to deliver content to the learners? (This question refers to theory only and not to the use of exam type questions in classroom discussions.) If you used other resources, please state what you used.

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5. **Q9:** If you used additional resources, please state why? (e.g. maybe you found content in the CAIR to be incorrect, irrelevant or not comprehensive enough – or maybe you just prefer to use more than one resource. If you identified problems with content in the CAIR, please identify the sections that were lacking)



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6. **Q10:** Some teachers stated that there were too few examples in the CAIR and some stated that there were enough. Did you feel that the number of examples was adequate as a first introduction to the content or would you have wanted more?

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7. **Q10:** If you found that the number of examples in the CAIR was enough for an initial introduction, did you need to do any others later in class or did you feel that these examples were chosen carefully enough to address all the necessary issues in mechanics to prepare learners for tests and exams?

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## **Training material**

This section contains the actual courseware (training material) that was used during the training process. The material is presented here under the same headings that were used in the previous section.

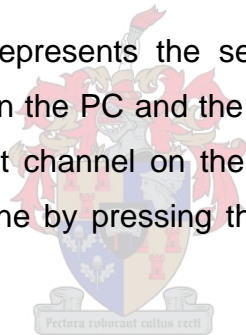
### **1. Technical background**

#### **1.1 Hardware requirements**

Hardware represents the physical electronic components that are needed to do the presentations in the classroom. These can be listed as follows:

- Personal computer - Consists of the computer, monitor, keyboard and mouse.
- PC to TV card - This is a special video card that is already installed in your computer and that makes it possible to connect your computer to a television.
- S-video cable – A cable that connects the PC to TV card in your computer to the television.

The equipment described above represents the setup that you will be using in your classroom. After having switched on the PC and the TV, it is important to make sure that you have selected the correct input channel on the TV to make the image on the PC, visible on the TV. This can be done by pressing the TV/AV button on the TV until the picture becomes visible.



Images on a PC can also be enlarged for presentation purposes by using a projector that is connected to the PC. This then projects the image onto a screen. This is the system used in the TRAC laboratory.

#### **1.2 Software requirements**

The usual way in which presentations are done is to use a software package that can be used to produce slides. The slides are then projected using one of the methods in the previous section. Examples of software packages that make this possible are PowerPoint (Microsoft), Presentations (Corel) or Impression (Sun). However, there are a few problems with these. The teacher can accidentally change content of slides. If they don't know how to use the software packages to correct the changes, the shows will not work as was intended by the developer. Although there are viewers available that view the slides without the original software installed, these viewers often do not make it possible to view videos or other formats of animation. Schools would therefore need to install the editing

software to view the shows correctly. This means an extra cost and the danger of teachers accidentally changing the slide shows.

It was therefore decided to develop a system of slides that cannot be accidentally edited by the teacher and that does not need special, costly software to be viewed. These slides were developed using the same process that is used to make web pages. The slides are actually web pages that can be viewed in a browser. This package specifically makes use of Microsoft's Internet Explorer 4 (or later) for viewing. As this browser is legally obtainable via a free download off the Internet, it means no extra costs of software for schools. However, while the slide show is being displayed, one may not even realise that Internet Explorer is used as the viewing software, as it appears different to what one would be used to when using the browser on the Internet. The next session will show how to access the files on the computer.

## 2. File management

### Where do I usually find the slide shows?

The slide shows can be accessed in different ways on the computer. Four ways will be discussed here.

#### 2.1 On the desktop

There will be a folder on your computer's desktop that will be named **TRAC Presentations**. Here is an example:

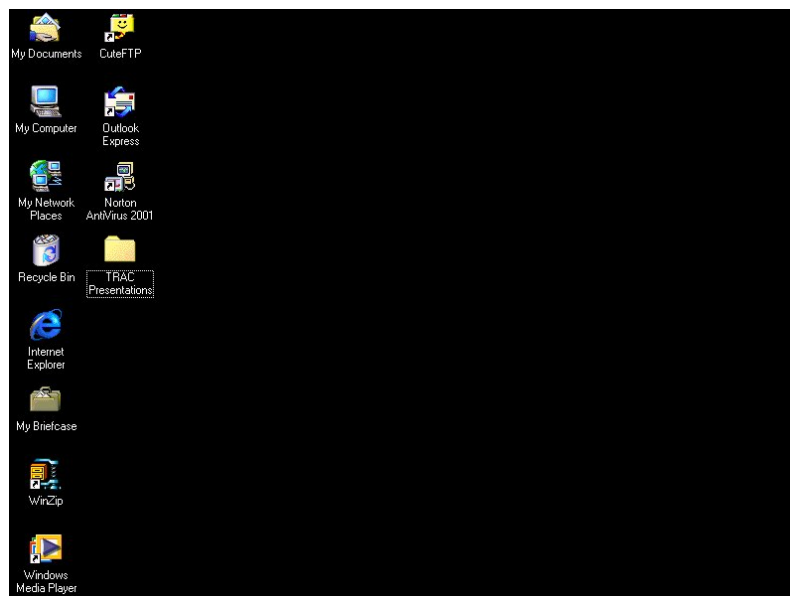
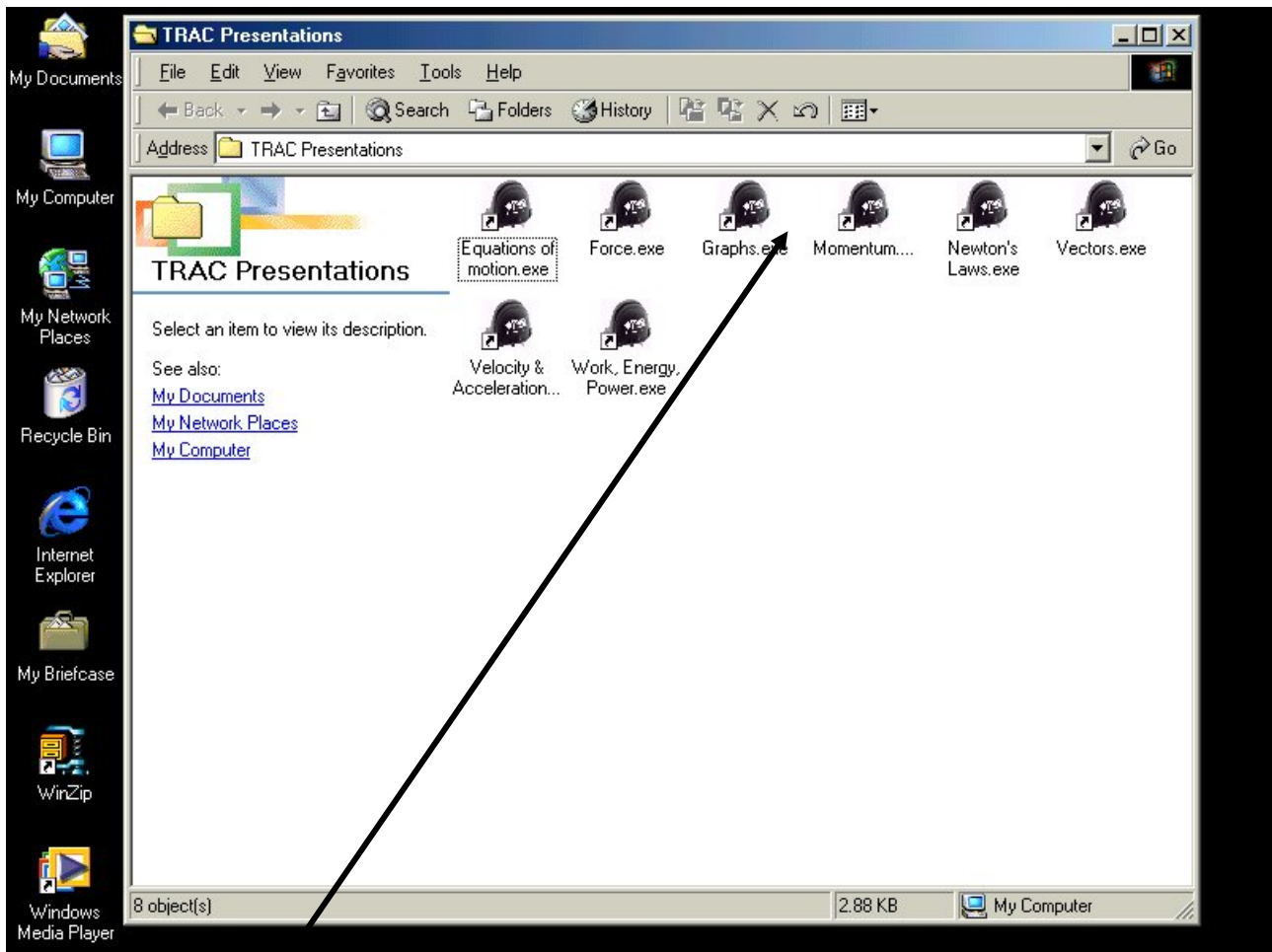


Figure 26: Example of TRAC Presentations folder on the desktop

Double clicking on the TRAC Presentations folder icon, opens a new window that displays the eight slide shows. Double clicking on any one of these will start the show.

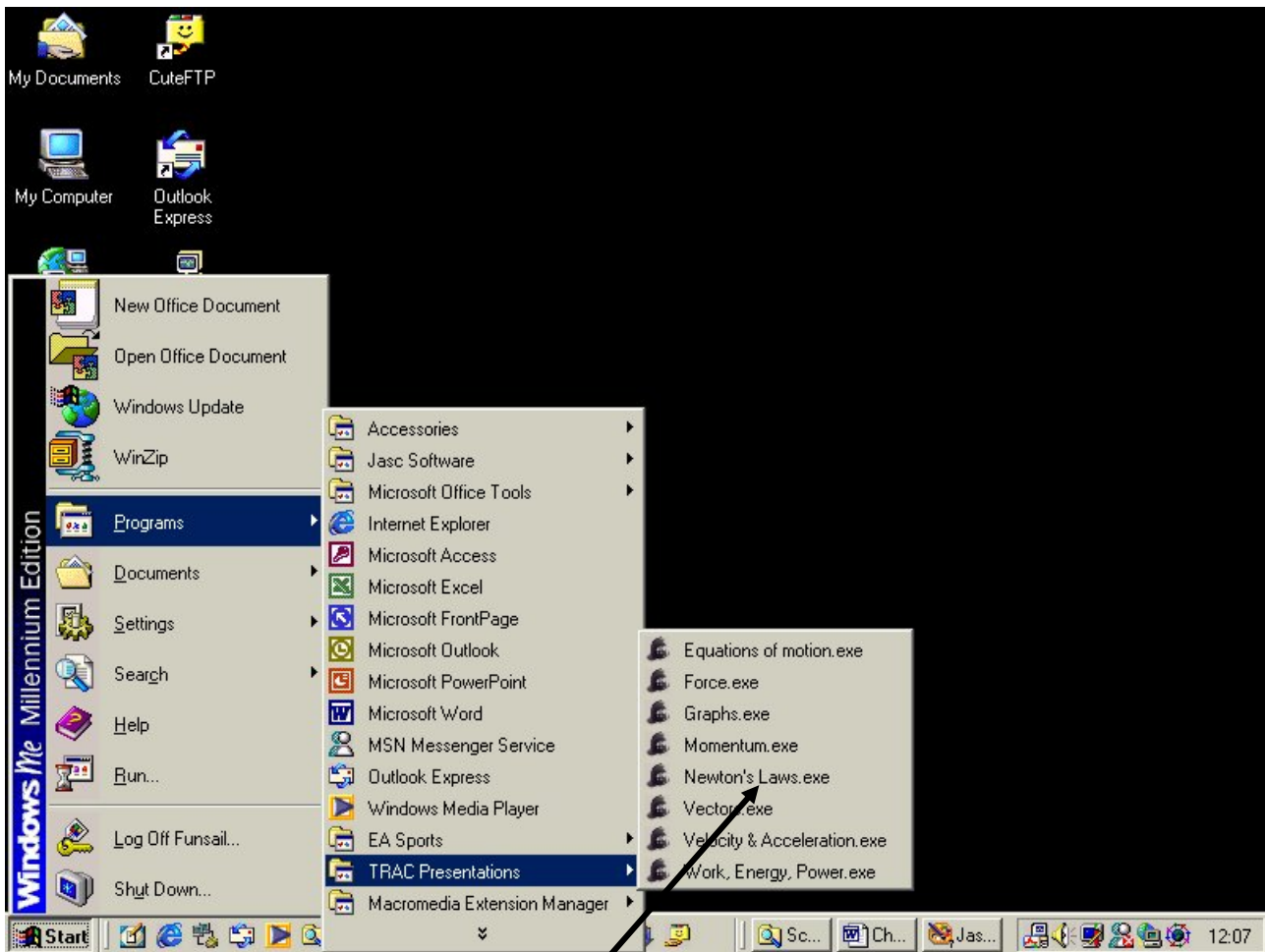


Click on any of these to start the desired slide show.

**Figure 27: The TRAC presentations folder**

## 2.2 Using the Start Menu

The slide shows can also be accessed via the Start menu. This can be done by clicking on Start on the Task bar. From there choose programs and then TRAC Presentations. Clicking on any one of the slide shows will start it.

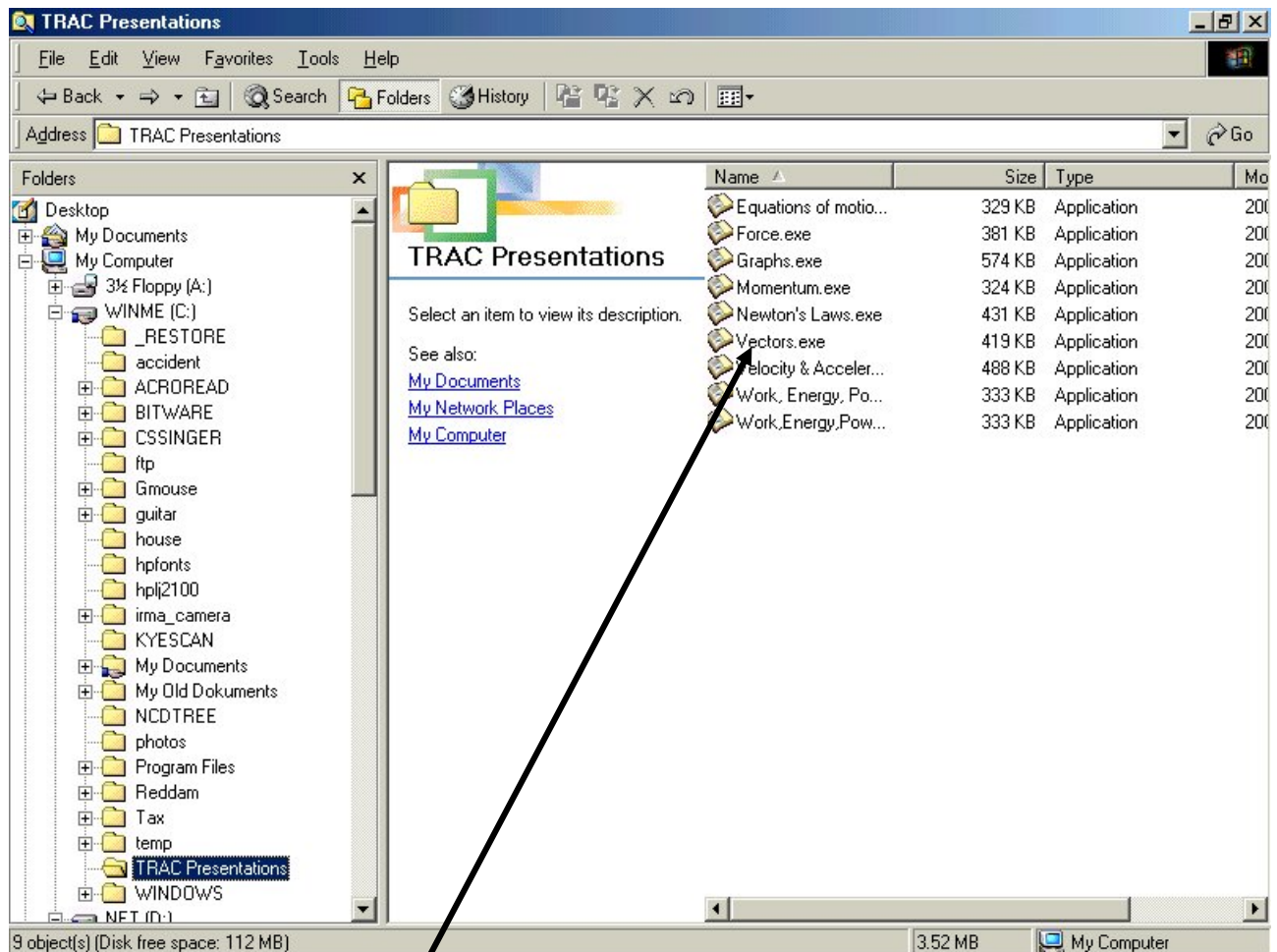


Click on any of these to start the desired slide show.

**Figure 28: Using the Start menu**

### 2.3 Using Windows Explorer

In Windows Explorer you will find a folder on the C drive called TRAC Presentations. Clicking on that will reveal the files in the pane on the right-hand side of the Explorer window.



Click on any of these to start the desired slide show.

**Figure 29: Using Windows Explorer**

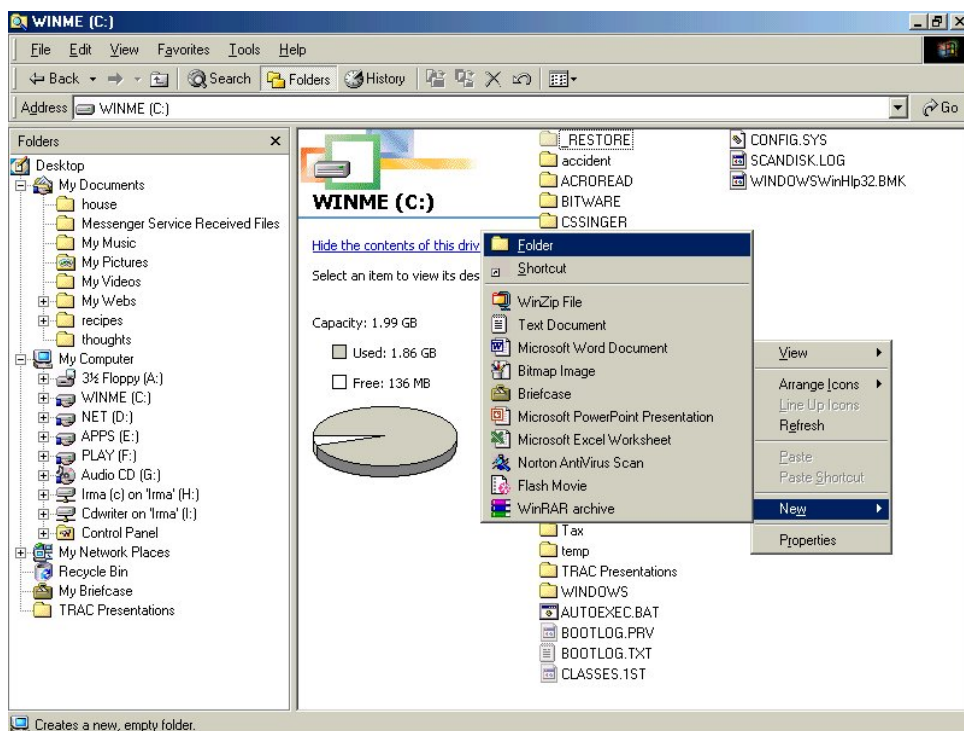
## 2.4 Using the CD

If anything should go wrong and the software needs to be copied to the hard drive again, the files are all available on the CD. Use Windows Explorer to access the files on the CD just as you accessed them on the C drive in the previous example. The only difference is that your CD ROM drive is probably your D drive.

You can either run the shows directly off the CD or you can make a new folder on your C drive and simply copy them there.

The following steps can be followed to copy the files to the C drive.

- Open Windows Explorer and click on the C drive.
- Now right click in the right-hand pane and choose *New* and then *Folder*.



**Figure 30: Copying files to the hard disk drive**

- Give the folder a name like TRAC Presentations.
- Now select all the files on the CD in the TRAC Presentations folder on the D drive.
- Choose the Copy command under the Edit menu.
- Go back to the TRAC Presentations folder you made on the C drive and choose the Paste command under the Edit menu.



Files can now be executed from the C drive again using the method described for Windows Explorer. Please take note that Windows Explorer and Internet Explorer are two different applications. The first one is used to manage files and the second is used to browse the Internet.

### 3. Using the CAIR

Using the Computer-Aided Instructional Resource (CAIR) means accessing one of the eight executable files first. To do that you must use one of the four methods described in the previous section.

Having executed the file, the first slide will appear. This is the navigation slide for the specific slide show that you have chosen. It is different from the other slides in that it makes it possible for you to navigate to any slide in the slide show. The following image shows the navigation slide for Vectors.exe.

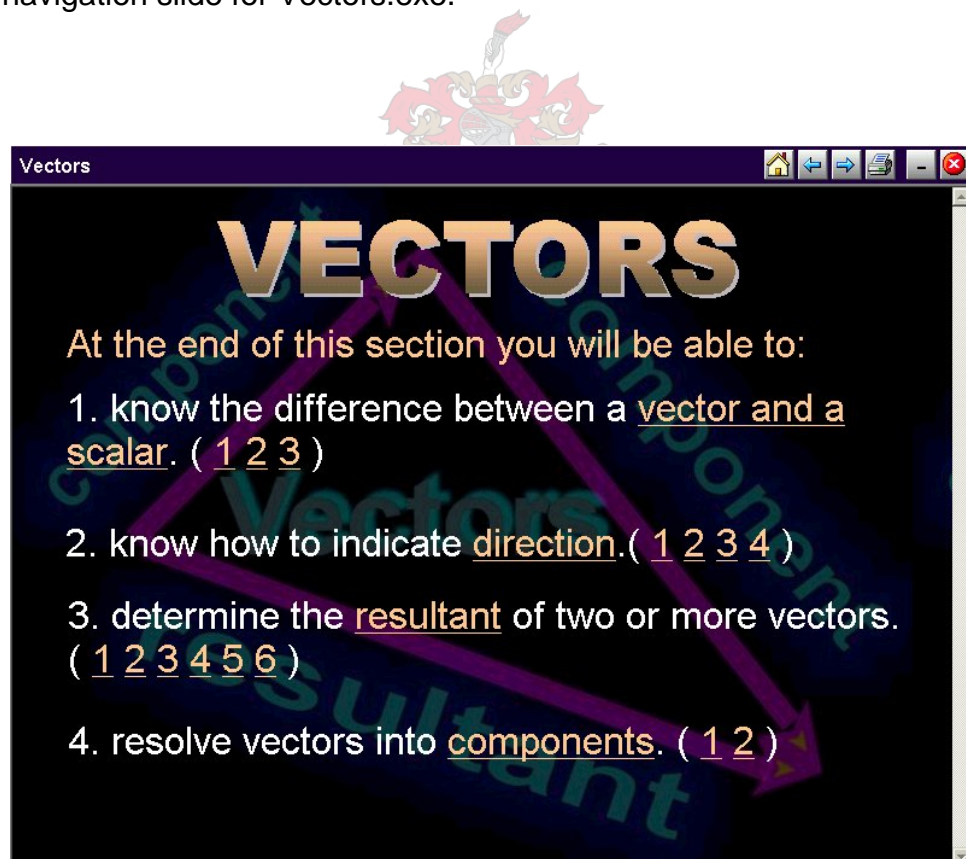


Figure 31: The navigation slide for Vectors.exe



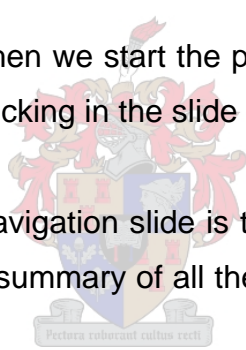
### 3.1 The navigation slide

When the slide comes up the first time, you will see only the heading. You have to click somewhere in the slide window to bring up points 1 to 4. Each one of the points have a number of digits in a bracket at the end. These numbers represent the slide numbers in that section. We can therefore see that there are four slides in section two and six in section three. Clicking on a slide number will take you to that exact slide. If you had therefore started with the slide show on vectors today and came up to slide number two in section two, then you can easily continue from slide two tomorrow by clicking on slide number two in section two.

The words that are underlined in each section are also links. Clicking on the underlined words will always take you to the first slide in that section. One would therefore start a new slide show by either clicking on the underlined words in the first section or by clicking slide number one in brackets at the end of the first section.

The navigation slide is used only when we start the presentation. After that the next slide comes up automatically by simply clicking in the slide currently being viewed.

Although the main function of the navigation slide is to navigate through the slide show, it also gives the learner a very useful summary of all the sections covered under a particular topic.



### 3.2 Controlling the flow of information

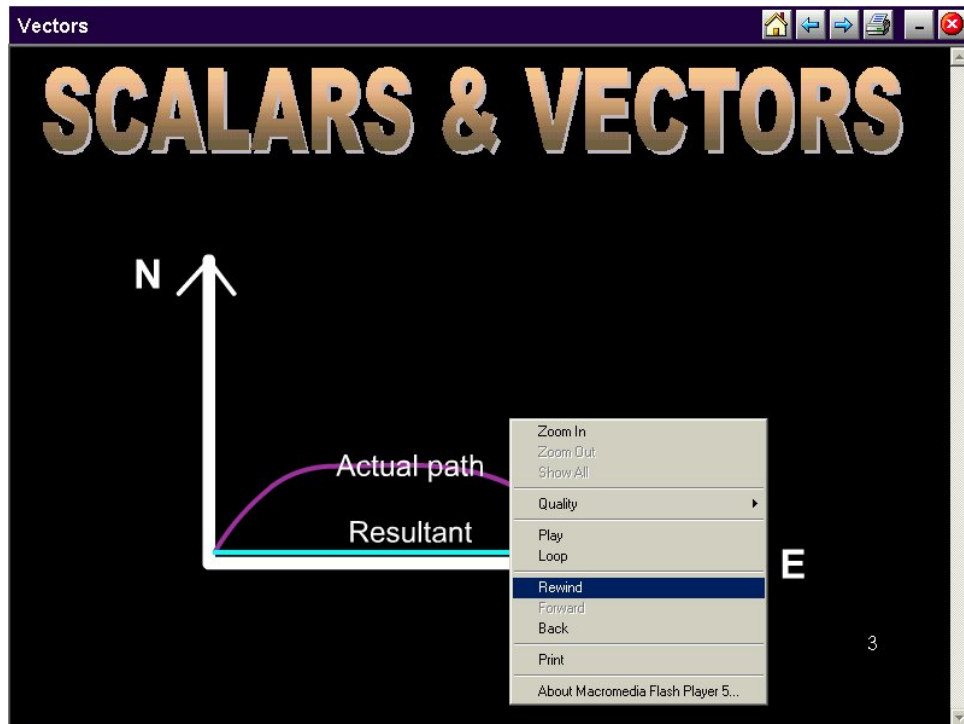
Information is presented by clicking somewhere in the slide window. Every time you click, a new piece of information appears. This gives you the opportunity to focus only on the new information that has appeared. This is the same as uncovering an overhead transparency by pulling down a piece of covering paper for every new point that you want to reveal.

One of the main advantages of using this resource is that some of the information can be represented as animations. There are a few things that need to be remembered about the animations.

- If an animation is revealed (by clicking somewhere in the slide window) it will start playing immediately without any further prompt from you. Some of the animations

have been timed to have a time delay before starting so that the learner can absorb the information.

- If you right click on an animation, a quick menu is activated that makes it possible to rewind the animation or to go forward or backwards in little steps. The following image shows this menu.



**Figure 32: Using quick menus**

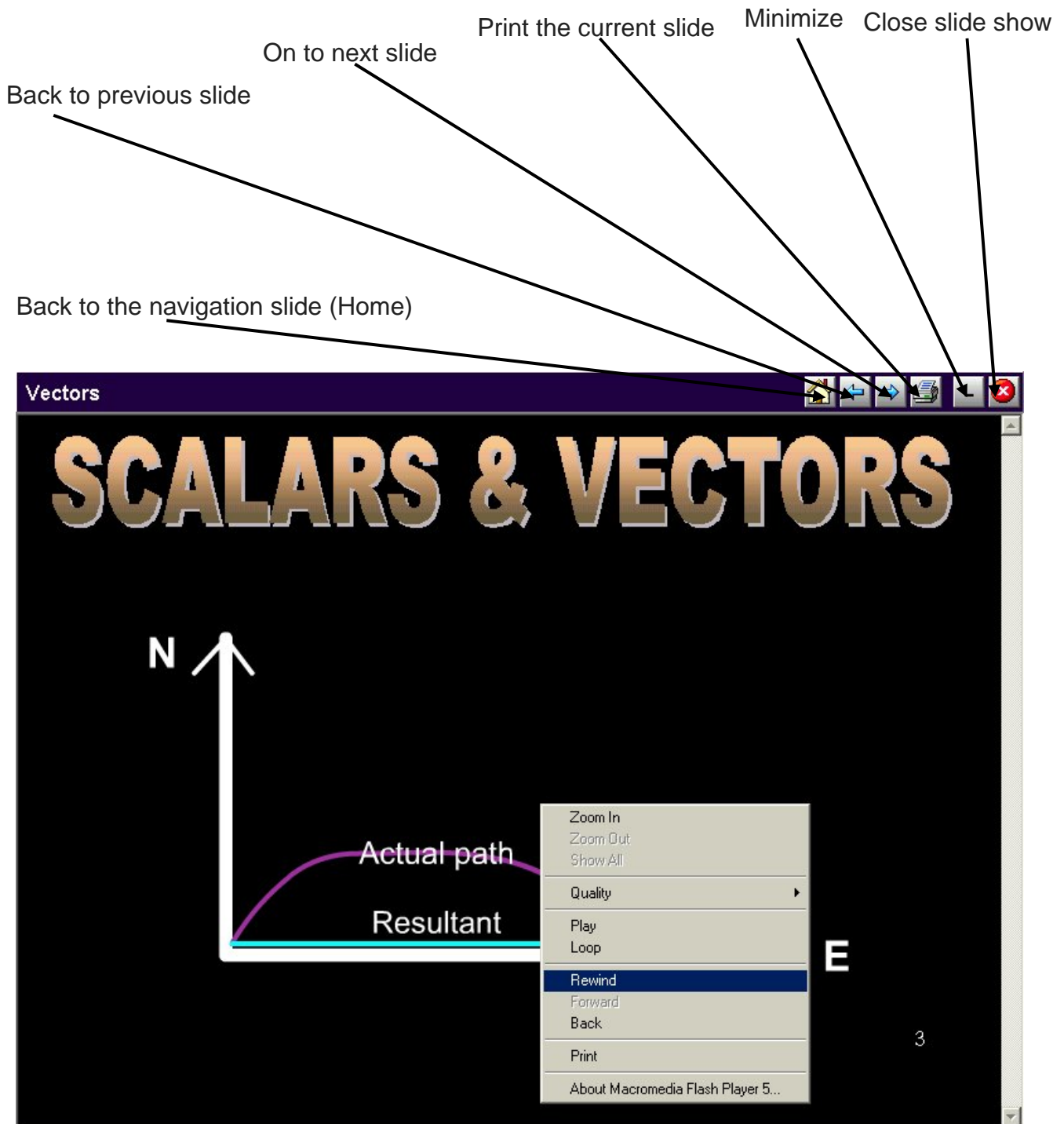


This makes it possible for learners to view an animation as many times as they need.

- To make the right click in the animation possible, it means that left clicking on it will have no effect on the slide show. In other words one must be careful to place the mouse pointer off the animation when clicking to reveal the next bit of information. If you are unsure where to click, you can click on the heading at the top. This will always reveal the next bit of information or take you to the next slide when the end of the current slide is reached.

### 3.3 The slide window

You will notice that the slide window has a bar at the top with a number of icons on the right. The following image labels each of the icons.



**Figure 33: Uses of icons on the slide window**

You would probably never need to use the print option as you are given a set of printed notes to copy for the students. As every slide can be navigated from the navigation slide the forward and back buttons are not really necessary either.

## Examples of TRAC practical sheets

### Activity 1 Reference Points and Directions

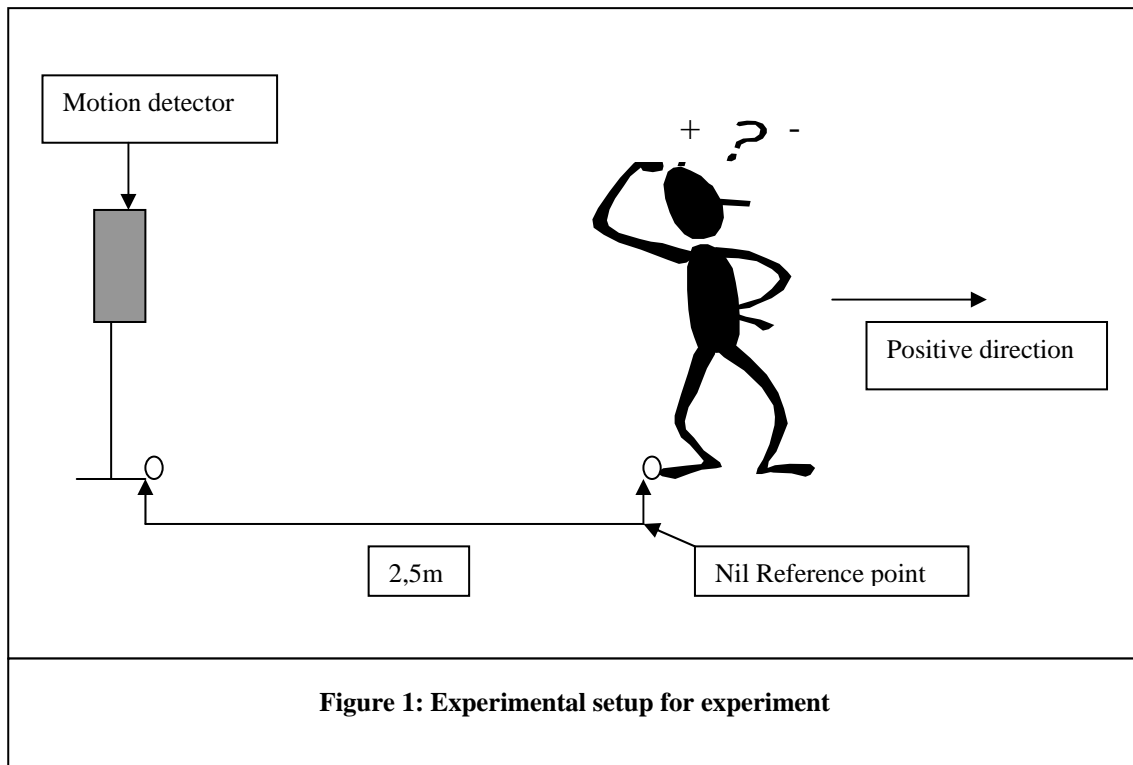
Name: \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

Experiment files: `verwys1.exp` & `verwys2.exp`

When you have completed this experiment you should be able to:

- Understand and explain the terms "Reference point" and "Reference direction"
- Interpret and simulate the movement displayed on a displacement/time graph.
- Explain how the choice of reference direction influences the shape of a displacement/time graph.



### Important definitions

#### Reference Point

Point or position from which displacement is measured

#### Displacement(s)

The magnitude and direction of the straight line drawn from the starting point to the end of the motion of an object.

## Reference Point

1. Place the motion detector on a chair or in a stand with enough room in front of it.
2. Measure a distance 2,5m from the sensor and mark the point with chalk on the floor.
3. Do not move the sensor now.
4. The point will serve as the reference point for the experiment.

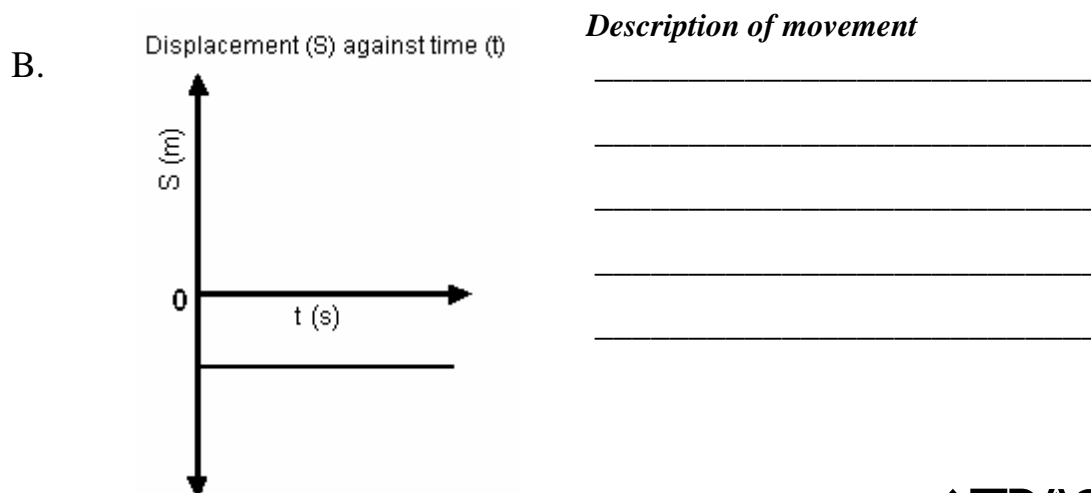
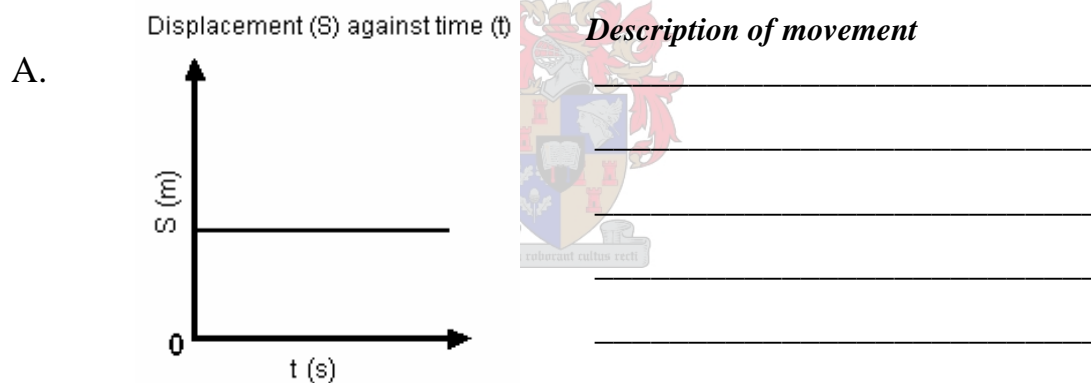
## Part I

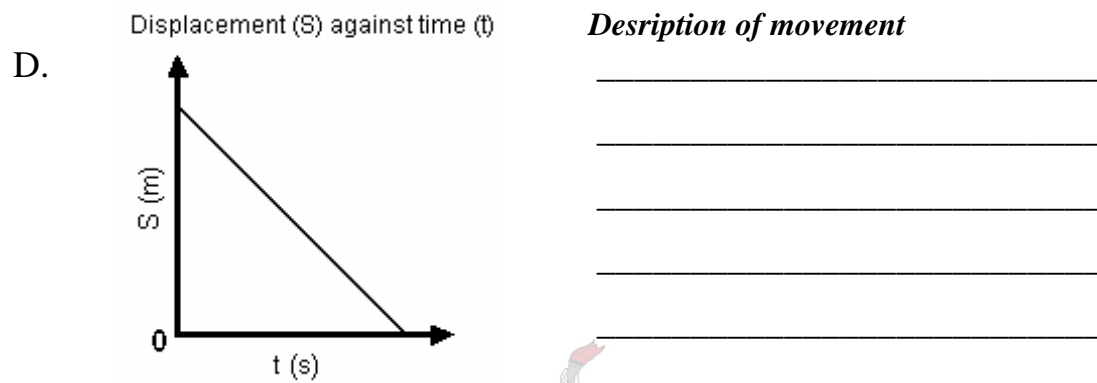
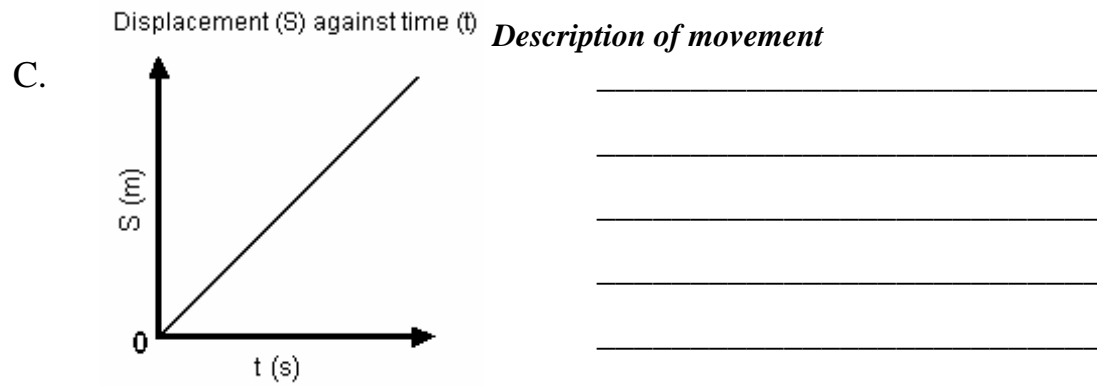
1. Open the file **verwys1.exp**
2. Displacement **away** from the sensor is measured as **positive**.

## Interpretation of graphs

The following are examples of Displacement vs. Time Graphs.

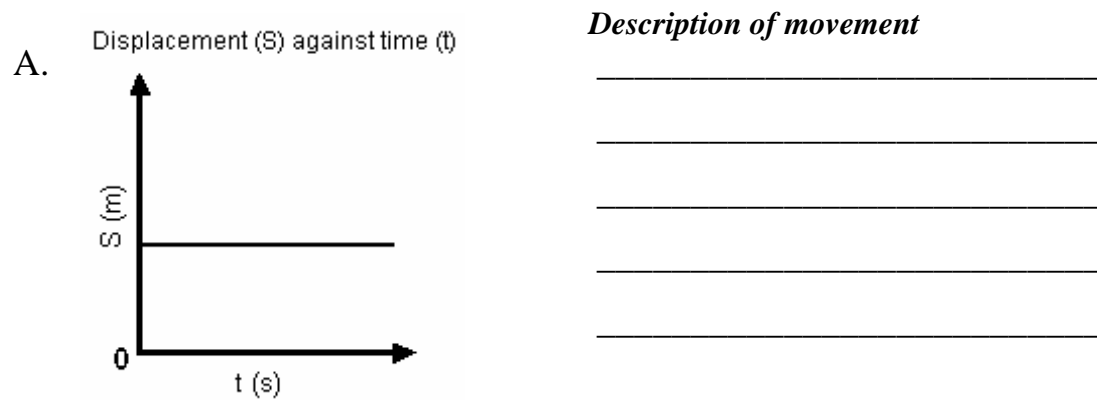
1. Discuss the motion displayed by each graph.
2. Try to imitate the movement displayed in each graph by letting one person move in front of the sensor.
3. Click on **Start** to record the movement.
4. Give a short explanation of the movement next to each graph.





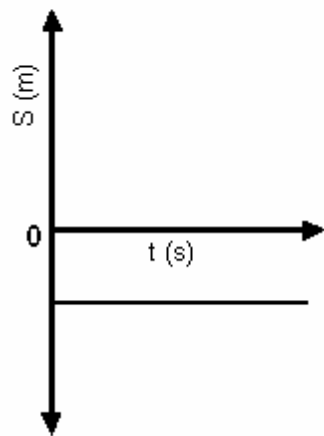
## Part II

1. Open the file **verwys2.exp**.
2. The mark on the floor is still the reference point, but movement **towards** the sensor is now taken as positive.
3. Imitate the graphs below again by simulating the motion.
4. Explain the motion.



B.

Displacement (S) against time (t)

*Description of movement*


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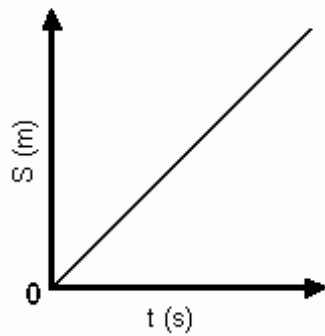
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C.

Displacement (S) against time (t)

*Description of movement*


---

---

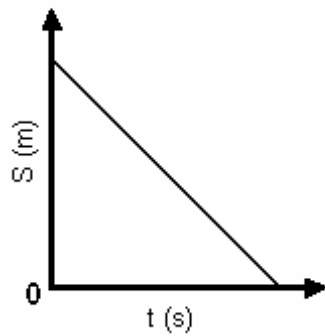
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D.

Displacement (S) against time (t)

*Description of movement*


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## Activity 2.1

### *The relationship between mass and acceleration*

Name: \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

Experiment file: **forc&ac2.exp**

#### **On completion of this activity, you should be able to:**

- Explain how the mass of an object influences its acceleration.
- Explain the relationship between mass and acceleration graphically.
- Explain the relationship between mass and acceleration mathematically.
- Use the relationship to solve problems.

(Your teacher will assess whether you have achieved these criteria in the assessment tasks he/she sets.)

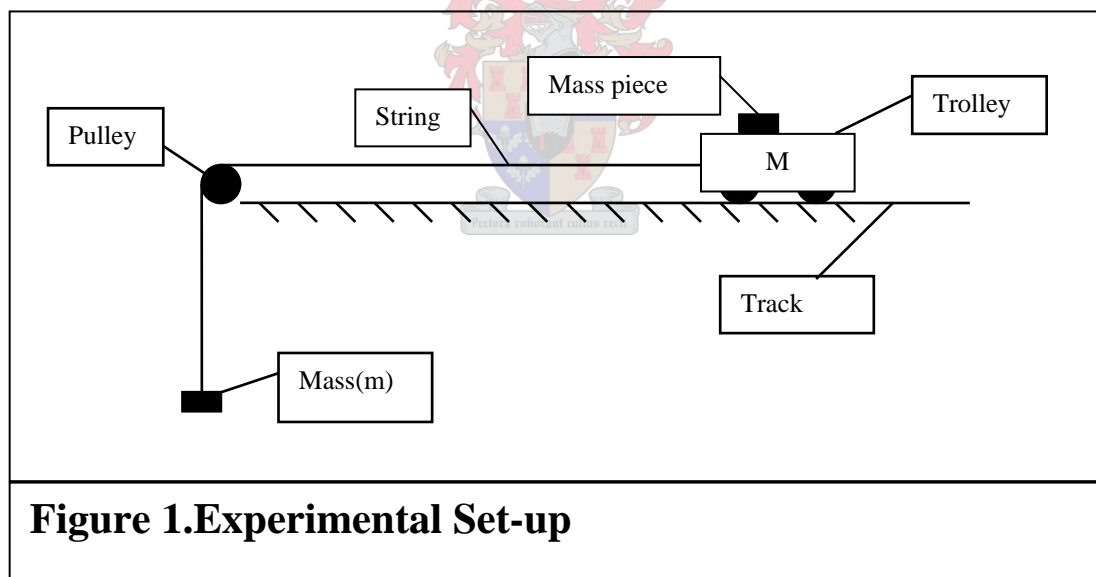
#### Terminology

**Weight:** The force with which a body is pulled towards the centre of the earth.  $W=mg$   
**Resultant Force** The single force which has the same effect as all the original forces exerting on a body.

**Acceleration:** *The rate of change in the velocity of a body.*

#### Experimental set-up

Set up the apparatus as shown in the diagram below.





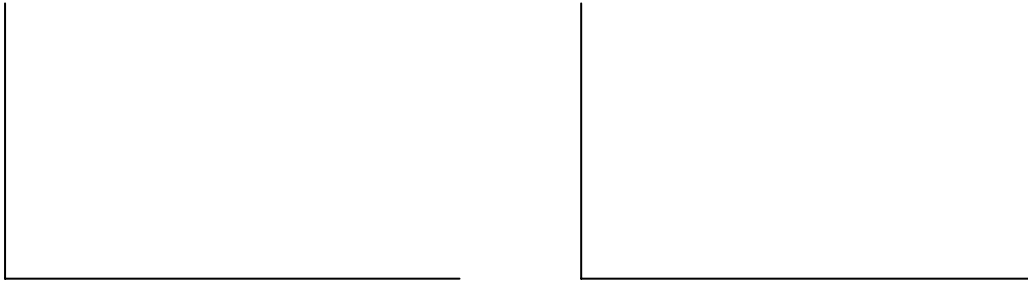
## Procedure

Discuss these questions in groups before continuing with the investigation.

1. We are investigating the acceleration of a moving system in this experiment. Name the parts of the system.

.....

2. Make use of the following axis and draw rough sketches which represent Newton II. Label the axes clearly.

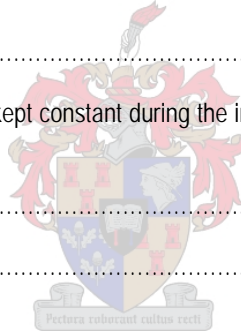


3. We are trying to establish the relationship between two variables in this investigation. Name the two variables?

.....  
 .....

4. All other quantities must therefore be kept constant during the investigation. Name the variables that should be kept constant.

.....  
 .....



5. Give a reason why the physical quantity named in question 4 should be kept constant.

.....  
 .....

6. In the experiment the force is kept constant and the mass changed. How will these conditions be maintained through the whole experiment?

.....  
 .....

Work in small groups to carry out the following instructions.

- Open the file Forc&ac2.exp in the MPLI programme.
- Weigh the trolley \_\_\_\_\_ kg
- What is the mass of the system? \_\_\_\_\_ kg
- Attach the string to the trolley and place the trolley at the top of the track.
- Simultaneously release the trolley and click on **START**.
- If the results look reasonable, click on **DATA** then click **STORE LATEST RUN**.



- Place mass pieces on the trolley to increase the mass of the trolley. Write down the total mass of the trolley and the mass pieces. \_\_\_\_\_ kg

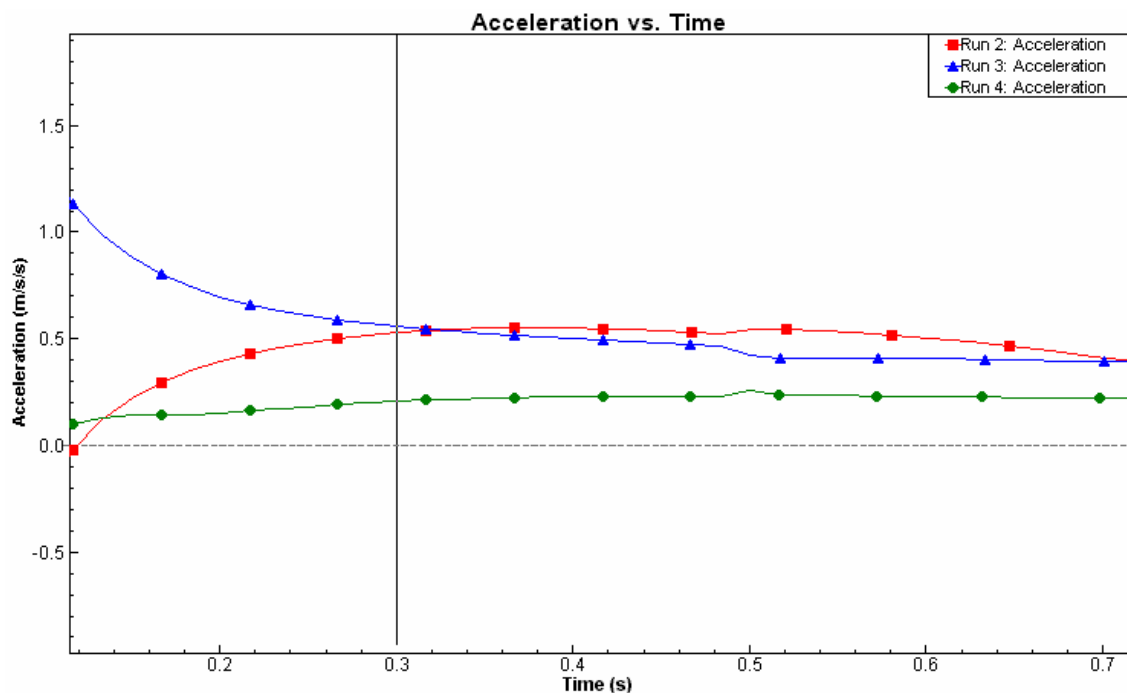
- Repeat the experiment twice. Increase the mass pieces every time.

- Write down the total mass of the trolley and mass pieces of the other two runs.

\_\_\_\_\_ kg

\_\_\_\_\_ kg

- Display all the graphs on one axis. Make use of different colours to distinguish between the graphs.



- A typical example of the experiment graph is the following one:

### Analysis

**You should try to answer these questions on your own. Should you experience any problems ask your teacher for assistance.**

- Make use of the graph on the screen of the computer and determine if the change in mass of the system influences the acceleration.

.....  
 .....

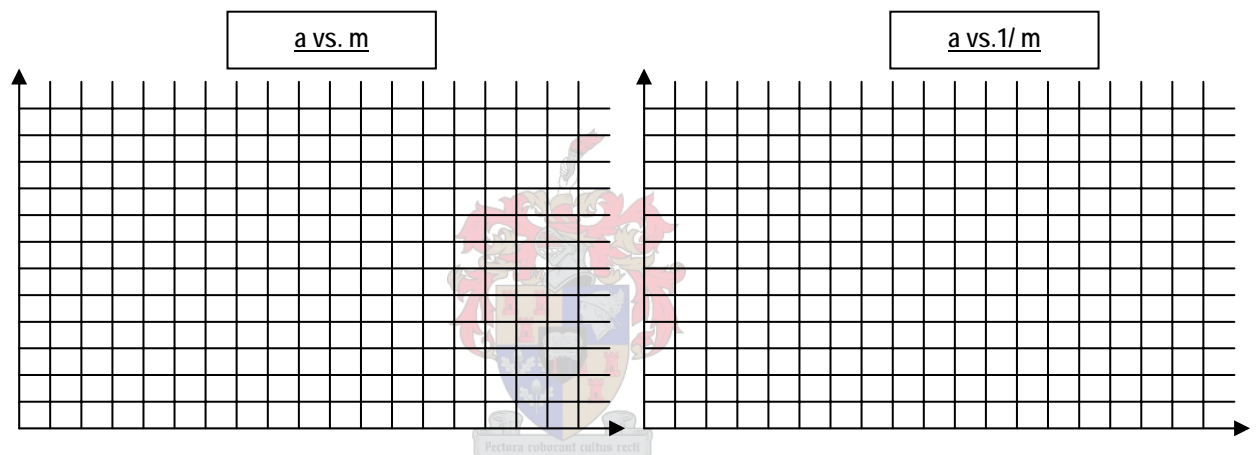
2. Determine the magnitude of the constant force that is exerted on the system.

.....  
 .....

3. Complete the following table.

Run	a (ms <sup>-2</sup> )	m (kg)	1/m kg <sup>-1</sup>
1			
2			
3			

4. Use the above information and plot graphs of  $a$  vs  $m$  &  $a$  vs.  $1/m$ .



5. Determine the gradient of the graph of  $a$  vs.  $1/m$ .

.....  
 .....

6. Discuss the form of the two graphs.

.....  
 .....

7. Explain the relationship which exists between the mass and the acceleration of a body.

.....  
 .....

8. Express this relationship as a mathematical equation.

.....

## Activity 2.2

### *The relationship between resultant force and acceleration*

Name: \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

Experiment file: **Force4.exp**

#### **When you have completed this activity, you should be able to:**

- Explain how the acceleration of an object changes when the resultant force acting on it increases or decreases.
- Express the relationship between resultant force and acceleration graphically.
- Express the relationship between resultant force and acceleration mathematically.
- Use these relationships to solve problems.

(Your teacher will assess whether you have achieved these criteria in the assessment tasks he/she sets.

#### Terminology

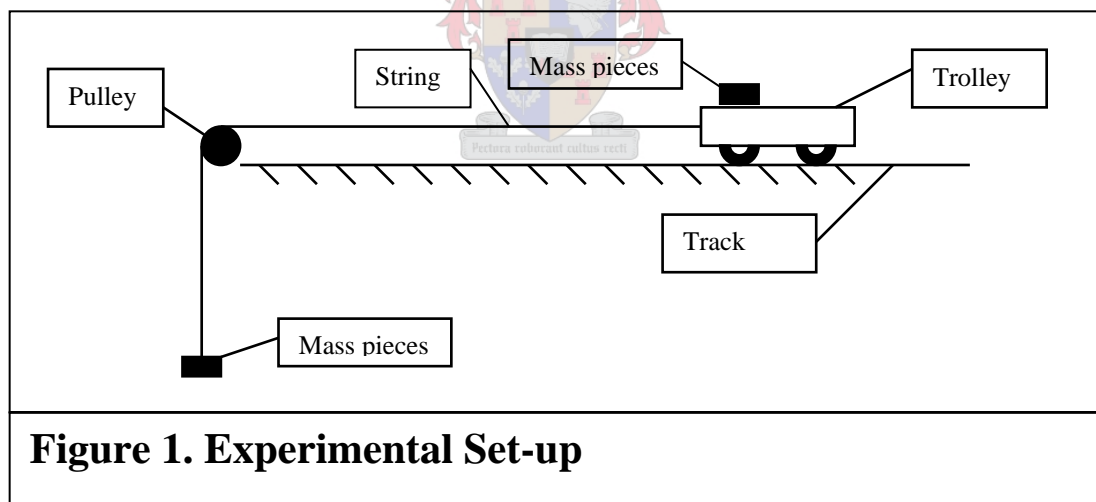
**Weight:** The **weight** of a body is equal to the product of its mass and the acceleration of gravity.  $W=mg$

**Resultant force:** A single force that exerts a force equal to all the other forces on a body

**Acceleration:** *The rate of change in the velocity of a body.*

#### Experimental set-up

Set up the apparatus as shown in the diagram below.



**Figure 1. Experimental Set-up**

Take note:


- The runway must be sloped to compensate for friction. To check, give the trolley a gentle push and allow it to run freely down the slope. Adjust the slope until the trolley moves down at a constant velocity.
- Use a thin, smooth length of string/ nylon cord and a frictionless pulley
- For best results, use mass-pieces of  $\pm 50g$  each. If a mass-holder is used, then its mass must be included in the total mass.

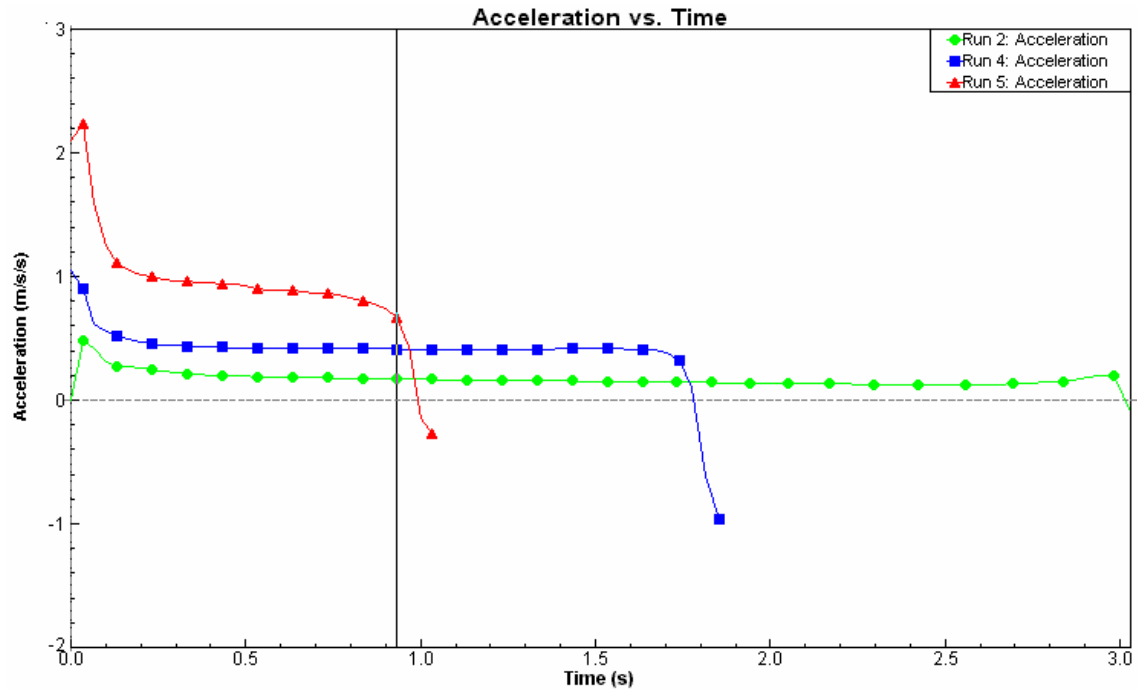
## Procedure

Discuss these questions in small groups or as a class before you continue with the investigation.

1. You will perform an experiment which investigates Newton II law. Name all the variables which are applicable to this law.  
.....
2. We are trying to establish the relationship between two variables in this investigation. Name the two variables?  
.....  
.....
3. The other variable must therefore be kept constant during the investigation. Name the variable.  
.....  
.....
4. You will be investigating the acceleration of a moving system in this experiment. Name the parts that form part of the system.  
.....
5. You need to supply a resultant force to cause the system to accelerate. How will you establish the resultant force?  
.....  
.....

Now work in small groups to carry out the investigation.

- Open the file Force4.exp in the MPLI programme.
- Attach a mass hanger to the end of the cord and tie the opposite end to the trolley. Pass the cord over the pulleys and pull the trolley up the slope so that the mass hanger lies just under the pulley. Place the mass pieces on the trolley.
- Simultaneously release the trolley and click on START  to collect data.
- If the results look reasonable, STORE DATA (Click on DATA, then STORE LATEST RUN). If the results are not reasonable repeat the run.
- Take the mass pieces off the trolley one-by-one and put them on the mass hanger. Allow the trolley to run down the slope after each new addition, and STORE the results if it look reasonable. Ideally, you should collect three sets of results, using different sets of mass-pieces to create the accelerating force.
- Display your graph sets so that they all appear on the same sets of axes. Use different colours to represent the different runs. An example of a graph of three runs is displayed on the next page.



### Analysis

**You should try to answer these questions on your own.**

The graphs you produced should be similar to the shapes of these shown above.

- 1 Explain why the acceleration/ time graphs are straight-line graphs parallel to the x-axis.

.....

.....

.....

- 2 How does the acceleration of the system change for each consecutive run?

.....

.....

- 3 What did you do with the mass-pieces to cause the change acceleration?

.....

.....

.....

- 4 What effect did the answer given for question 3 have on the resultant force acting on the system?

.....

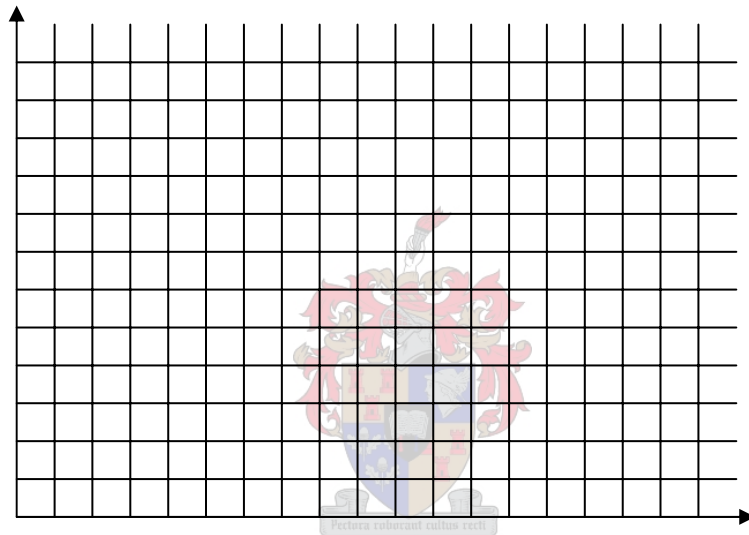
.....

Now measure the force that was applied for each run.

- 5 Complete the table below. Fill in the force that you measured for each run. Look at your graph and obtain the average acceleration for each run.

Run	Measured force (N)	Acceleration ( $\text{m.s}^{-2}$ )
1		
2		
3		

6. Now plot a graph of force against acceleration on the set of axes below.



7. Describe the shape of the above graph.

.....

.....

8. Explain briefly in words the relationship, which exist between resultant force and acceleration that is illustrated by the above graph.

.....

.....

9. Represent the relationship mentioned in question 8 as a mathematical proportionality.

.....

### Activity 3

## Simple Harmonic Motion of a moving Pendulum

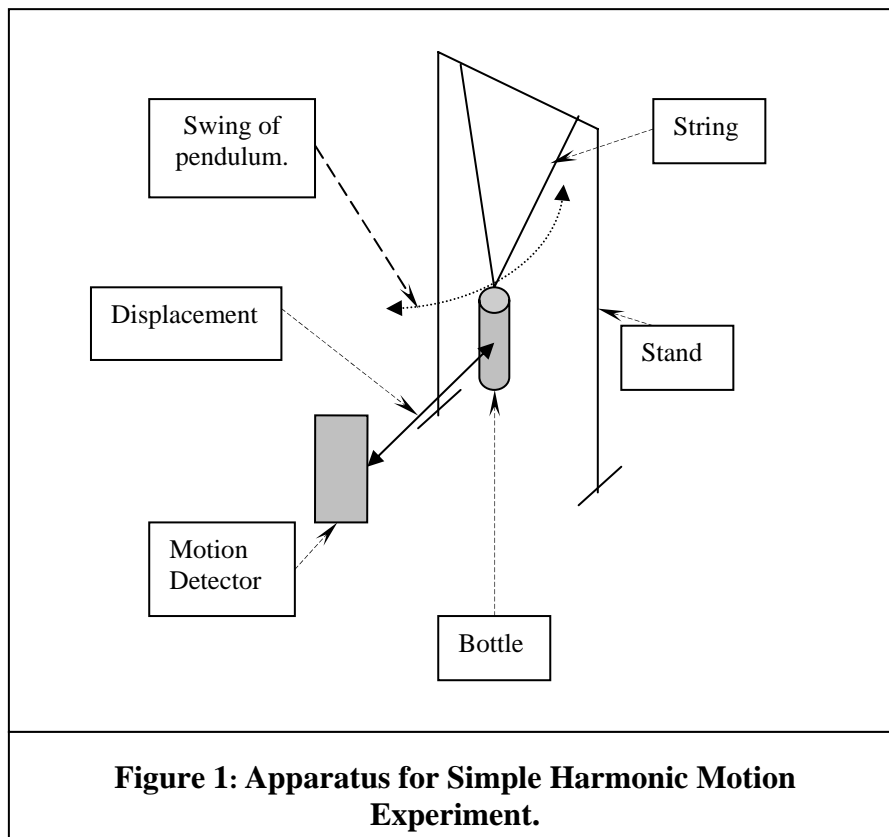
Name: \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

Experiment file **pendulum.exp**

When you have completed this experiment you should be able to:

- Explain the frequency of a swinging pendulum.
- Explain the period of a swinging pendulum.
- Discuss the relationship between frequency and period.
- Explain how the length of the pendulum influences its frequency and period.
- Explain how the mass of the pendulum influences its frequency and period.





### Important Definitions:

Period (T)                      The time (in seconds) for one complete oscillation.

Frequency (f)                The number of oscillation cycles per second.

Relationship between frequency (f) and period (T):      $f = \frac{1}{T}$

Points in Phase                Points are in “phase” when they are in a similar position on the wave diagram but in different cycles. Looking at Figure 2 we see that (A<sub>1</sub>, B<sub>1</sub>, A<sub>4</sub>, B<sub>4</sub>) are in phase.

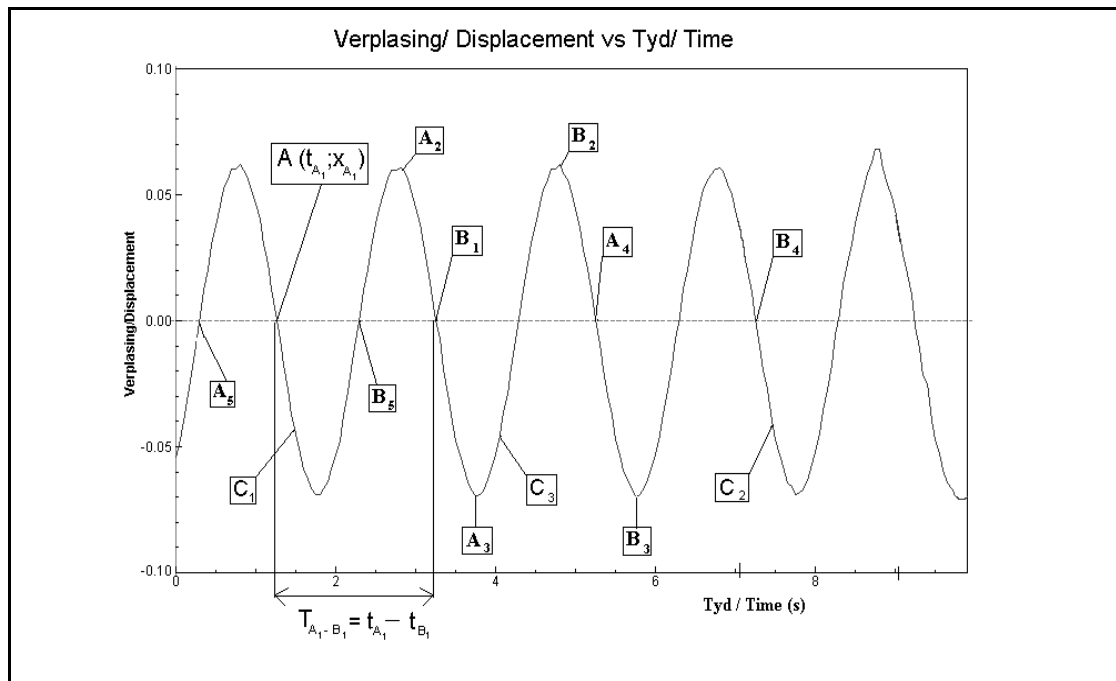


Figure 2: Graph of experimental results.

1. Write down all the other sets of in-phase points as shown in the example above.

---

2. Which marked points are not in phase with any other points?

---

$A_i = (t_{Ai}; x_{Ai})$

$A_i$  is a point on the **Displacement/ Time** graph with  $x_{Ai}$  and  $t_{Ai}$  as co-ordinates.

3. Identify the co-ordinates of point  $A_3$  on the graph in Figure 2.

---

### Procedure:

1. The file pendulum.exp will be used in the experiment.
2. Pull the pendulum backwards (100 mm) from its rest position.
3. Release it to swing freely.
4. Click "Start"
5. A **Displacement / Time** graph, similar to the graph given above, will be plotted on the screen in real-time.
6. To repeat, click on "Start" until you are satisfied with the graph.



*Pectus roboret cecus oculus*

## Part I

Use the Displacement/ Time graph you have generated to answer the following questions:

- Choose any two points ( $A_i$  and  $B_i$ ) in the same phase on the curve and record their time co-ordinates.
- Note how many oscillation cycles ( $n$ ) were completed between the time co-ordinates in (a).
- Repeat the procedure for four pairs of in- phase points.

	1	2	3	4	5
$t_{Ai}$					
$t_{Bi}$					
$n = \text{No. of waves}$					
$\left( \frac{t_{Bi} - t_{Ai}}{n} \right)$					

### Questions:

Use the balance at the back of the laboratory and determine the mass of bottle A. Write the value in the given space.

Mass of Bottle A = \_\_\_\_\_



- What do you notice regarding the values of row  $\left( \frac{t_{Bi} - t_{Ai}}{n} \right)$  in the above table?

---



---

- Determine the average value for  $\left( \frac{t_{Bi} - t_{Ai}}{n} \right)$ .

---



---

- What do you call the value calculated in question 2?

---

4. Use the calculated value in question 2, and determine the frequency of the pendulum.

---



---

## Part II

- a) Substitute bottle A with Bottle B.  
b) Complete the following table by repeating the procedure followed in Part I.

	1	2	3	4	5
$t_{Ai}$					
$t_{Bi}$					
n = No. of waves					
$\left( \frac{t_{Bi} - t_{Ai}}{n} \right)$					

### Questions:

Use the scale at the back of the laboratory and determine the mass of bottle B.

Write the value in the given space.

Mass of Bottle B = \_\_\_\_\_

1. Determine the average value for the period (as in Part I).

---

2. Does the mass of the pendulum have an influence on the period of the oscillation?

---

3. Does the mass of the pendulum have an influence on the frequency of the oscillation?

---

### Part III

- Detach the pendulum from the hook and attach the next set of loops so that the pendulum is shorter.
- Using the same mass as in Part I, follow the procedure, described in Part I to determine the period of the oscillation.

	1	2	3	4	5
$t_{Ai}$					
$t_{Bi}$					
$n = \text{No. of waves}$					
$\left( \frac{t_{Bi} - t_{Ai}}{n} \right)$					

### Questions

- Determine the average value for the period.

---



---

Compare the periods of the oscillations determine in Part I and III

- What influence does the length of the string have on the period of the oscillation?

---



---

- What influence does the length of the string have on the frequency of the oscillation?

---



---

*Activity 4*  
*Investigation of Free Fall, as a special*  
*case of Projectile Motion.*

Name: \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

Experiment file: **prjktl.exp**

When you have completed this activity, you should be able to:

- Define and explain the terms **Displacement**, **Velocity** and **Acceleration**
- Distinguish between the displacement/time, velocity/time and acceleration/time graphs of projectile motion.
- Explain the relationship between displacement, velocity and acceleration.
- Express the relationship between the displacement, velocity and acceleration graphs.
- Explain what happens to the three variables at the **turning point**.

(Your teacher will assess whether you have achieved these criteria in the assessment tasks he/she sets.

**Terminology:**

$t = \text{Time}$

**Displacement (s):** The magnitude and direction of the straight line drawn from the reference point to the object.

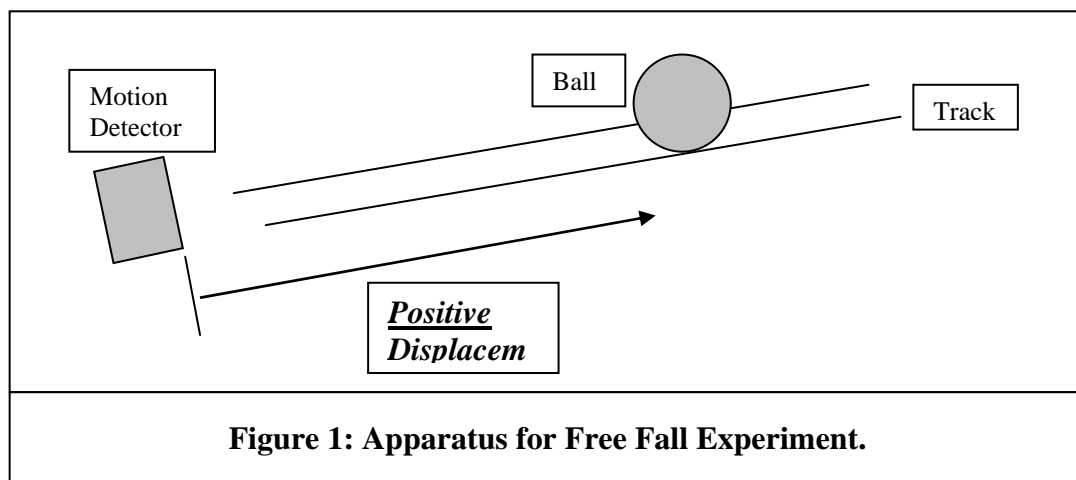
**Velocity (v):** The rate of change in displacement.

**Acceleration (a):** The rate of change in velocity.

**Turning Point:** A point where a change in direction of movement takes place.

**Experimental set-up**

Set up the apparatus as shown in the diagram below:



### Procedure:

Simulate free fall motion by rolling a ball up and down an incline to measure displacement, velocity and acceleration.

1. The apparatus and TRAC sensors are already calibrated to measure displacement away from the sensor as positive. See Figure 1.
2. Roll the ball up the incline and click on the "Start" button immediately.
3. Wait for the graph to be plotted on the screen.
4. Repeat the experiment until a smooth graph is obtained.  
(This might require some practise!)



### Analysis

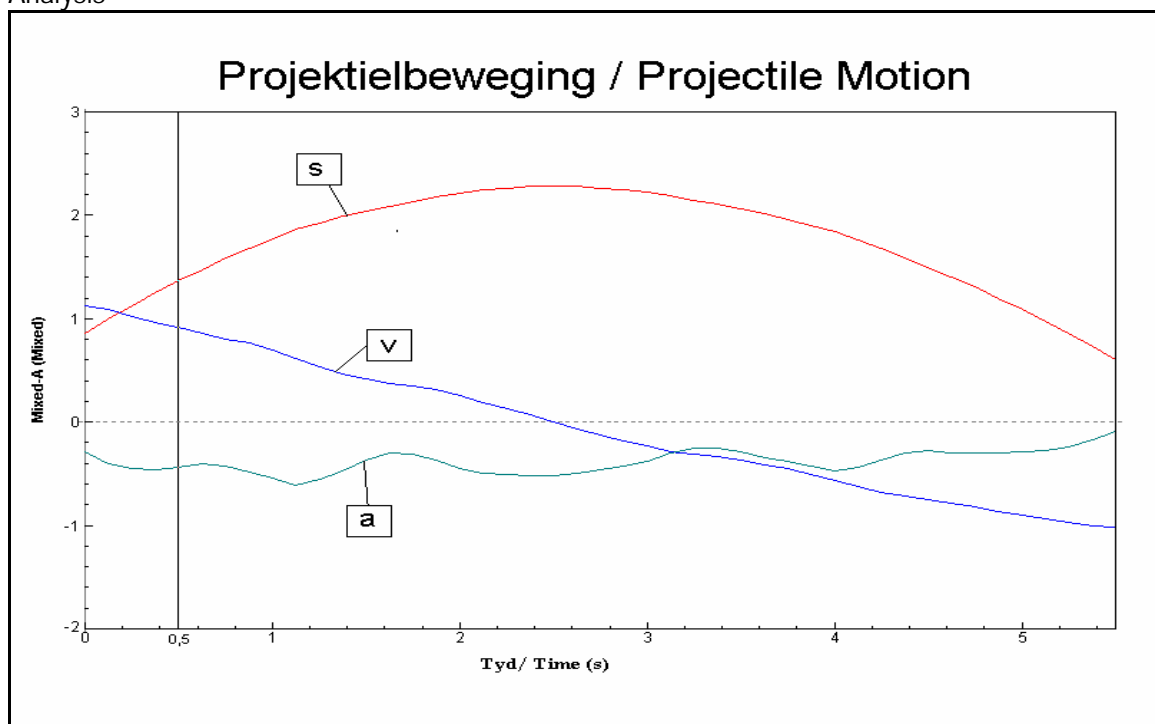


Figure2: Displacement, Velocity and Acceleration Graphs.

Use the graph on the screen, as well as the printed graph, to answer the following questions:

**Part I**

1. Draw a vertical line, on the printed graph, at time  $t_1 = 0.5$  s. Determine and record the displacement and velocity at this time from your experimental results.

$t_1$	0,5s
$s_1$	
$v_1$	

2. Indicate the turning point on the printed graph and draw a vertical line through it. Determine and record the time, displacement, and velocity at the turning point from your experimental results.

$t_2$	
$s_2$	
$v_2$	

What do you conclude? \_\_\_\_\_

3. Indicate by means of a vertical line on the graph, a time later than time  $t_1$  at which the displacement is the same as at time  $t_1$ . Determine and record the time, displacement, and velocity at this time from your experimental results.

$t_3$	
$s_3$	
$v_3$	

What do you conclude? \_\_\_\_\_

4. What shape do we expect for the **Acceleration / Time** graph? How does this compare to the experimental results?

\_\_\_\_\_

5. Determine from the graph the value of the **acceleration**. Is the value negative or positive?

\_\_\_\_\_

6. Determine the gradient of the **Velocity / Time** graph. Compare this value with the value determine in question 5.

\_\_\_\_\_



**Examine the Displacement / Time graph.**

7. What shape does the **Displacement / Time** graph have?

---

8. In what direction does the ball move when the velocity is positive?

---

9. In what direction does the ball move when the velocity is negative?

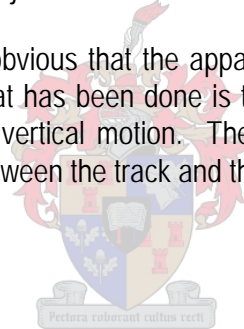
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10. What happens to the ball at the point where its velocity is zero?

---

**NOTES:**

- Free fall is a special case of projectile motion where the horizontal velocity component is zero.
- However, it is not necessarily obvious that the apparatus demonstrates either free fall or projectile motion. In effect, what has been done is to rotate the X-Y axes so that motion along the track represents the vertical motion. The gravitational effect is then equal to  $g \cdot \sin \theta$ , where  $\theta$  is the angle between the track and the horizontal plane.



**Activity 5*****Investigating the relationship between the motion graphs of uniform accelerated motion***

Name: \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

Experimental file: **accel.exp**

When you have completed this activity, you should be able to:

- Distinguish between displacement vs time, velocity vs time and acceleration vs time graphs.
- Determine the gradient of a graph.
- Express the relationship between the displacement, velocity and acceleration graphs.
- Use the relationships to solve problems.

(Your teacher will assess whether you have achieved these criteria in the assessment tasks he/she sets.)

**Terminology**

Displacement (s): The magnitude and direction of the straight line drawn from the reference point to the object.

Velocity (v): The rate of change in displacement.

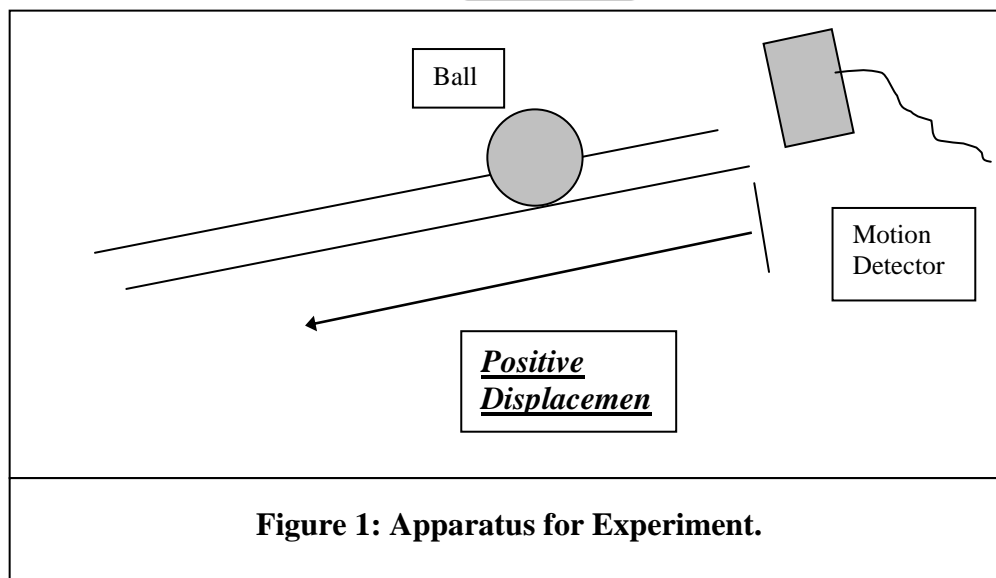
Acceleration (a): The rate of change in velocity

**Background knowledge**

(Focus on the chapter of uniform and accelerated motion in your textbook.)

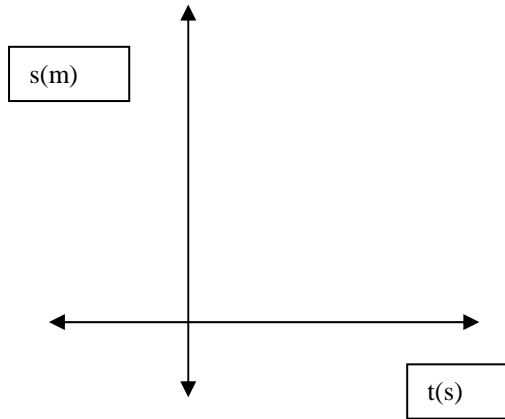
**Experimental set-up**

Set up the apparatus as shown in the diagram below:

**Part A****Procedure**

In this experiment we are investigating the relationship between the graphs of a constantly accelerated motion.

1. Hold the ball at the top of the incline and release it so that it starts moving from rest.
2. Study the movement of the ball closely. You may have to repeat the exercise a few times.
3. Use the following axes and draw sketch graphs of Displacement vs Time, Velocity vs Time and Acceleration vs Time. Describe why the graphs have the specific shapes in the space next to the axes.




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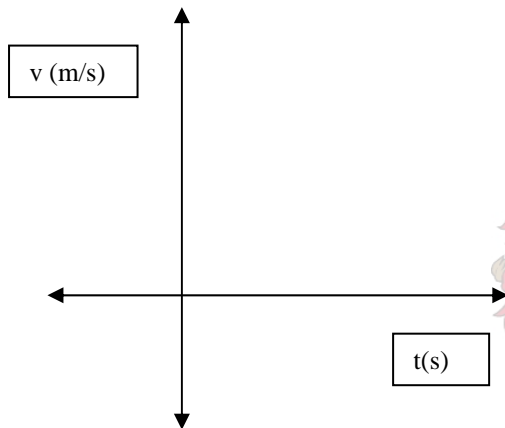
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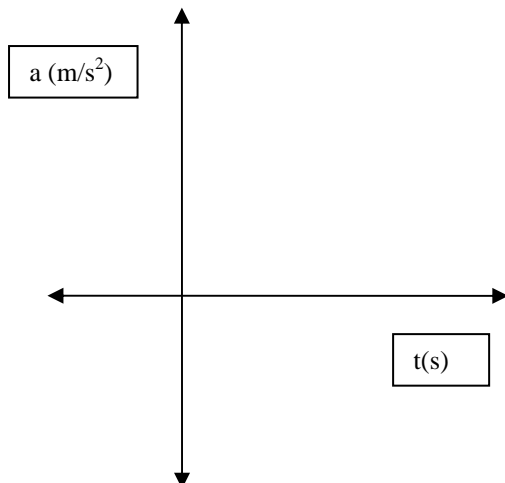
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**Answer the following questions:**

4. The gradient of the  $s/t$  graph gives the \_\_\_\_\_ of the motion.
5. The gradient of the  $v/t$  graph gives the \_\_\_\_\_ of the motion.

### Part B

Now work in small groups to carry out the investigation.

**Simulate constant accelerated motion by rolling a ball down an incline.**

5. The apparatus and TRAC sensors are already set up. See Figure 1.
6. Open the accel.exp file on the MPLI- Programme.
7. Let the ball run down the incline and click on the “Start” button immediately.
8. Wait for the graph to be plotted on the screen.
9. Repeat the experiment until a smooth graph is obtained.  
(This might require some practise!)

**Analysis**

Use your own results to answer the following questions.

**Displacement vs Time Graph**

1. What shape does the *Displacement vs Time* graph have?

---

2. How does this graph compare with the estimated graph that you've drawn in Part A?

---

3. Explain briefly why the graph has such a shape.

---

**Velocity vs Time Graph**

Click on the title of the y-axis of the graph. Click in the little square next to “Velocity” to activate that graph and then click “OK”.

1. What shape does the *Velocity vs Time* graph have?

---

2. How does this graph compare with the estimated graph that you've drawn in Part A?

---

3. Explain briefly why the graph has such a shape.

---

**Acceleration vs Time Graph**

1. What shape does the *Acceleration vs Time* graph have?

---

2. How does this graph compare with the estimated graph that you've drawn in Part A?

---

3. Explain briefly why the graph has such a shape?

---

### Relationships between Graphs.

Click on the Tangent Line-button:  
graph at



Now you will be able to read the value of the slope of the  
any point

Click on the Examine-button:



This will enable you to read the value of the graph at any point

1. Compare the value of the tangent/slope of the Displacement-Time graph to the value of the Velocity for a few points on the graphs. Is there any relationship between the values?

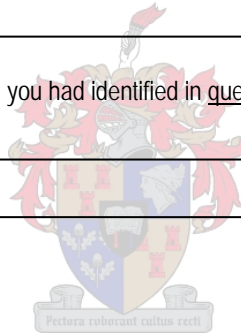
- 
2. Formulate briefly the relationship in words which you had identified in question1.

- 
3. Compare the value of the tangent/slope of the Velocity-vs Time graph to the value of the Acceleration vs Time for a few points on the graphs. Is there any relationship between the values

- 
4. Formulate briefly the relationship which you had identified in question3.

---

---



## Activity 6

### *Investigating the motion of a bouncing ball*

Name: \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

Experiment file: **Bounce.exp**

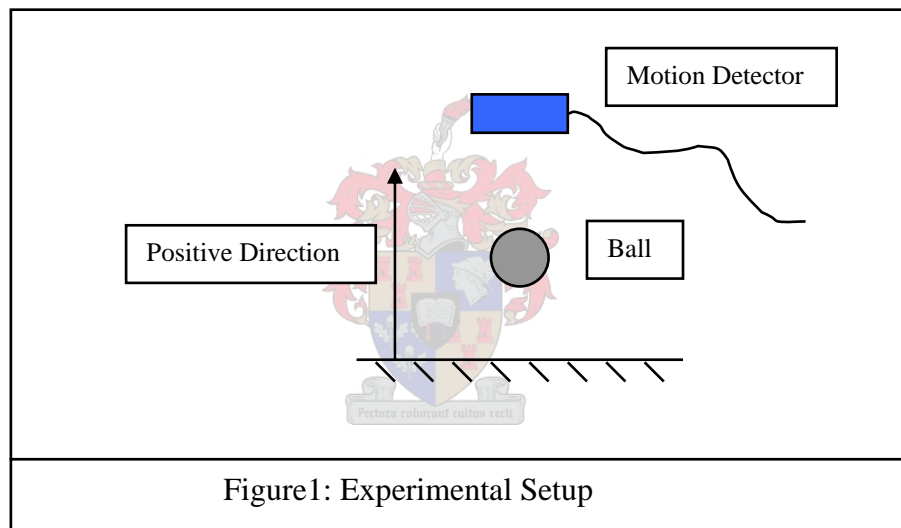
#### **When you have completed this activity, you should be able to:**

- Use a verbal description and graphical representations to describe the changes (if any) in the displacement, velocity and acceleration of a ball as it bounces up and down.

(Your teacher will assess whether you have achieved this criterion in the assessment tasks he/she sets.

#### Experimental set-up

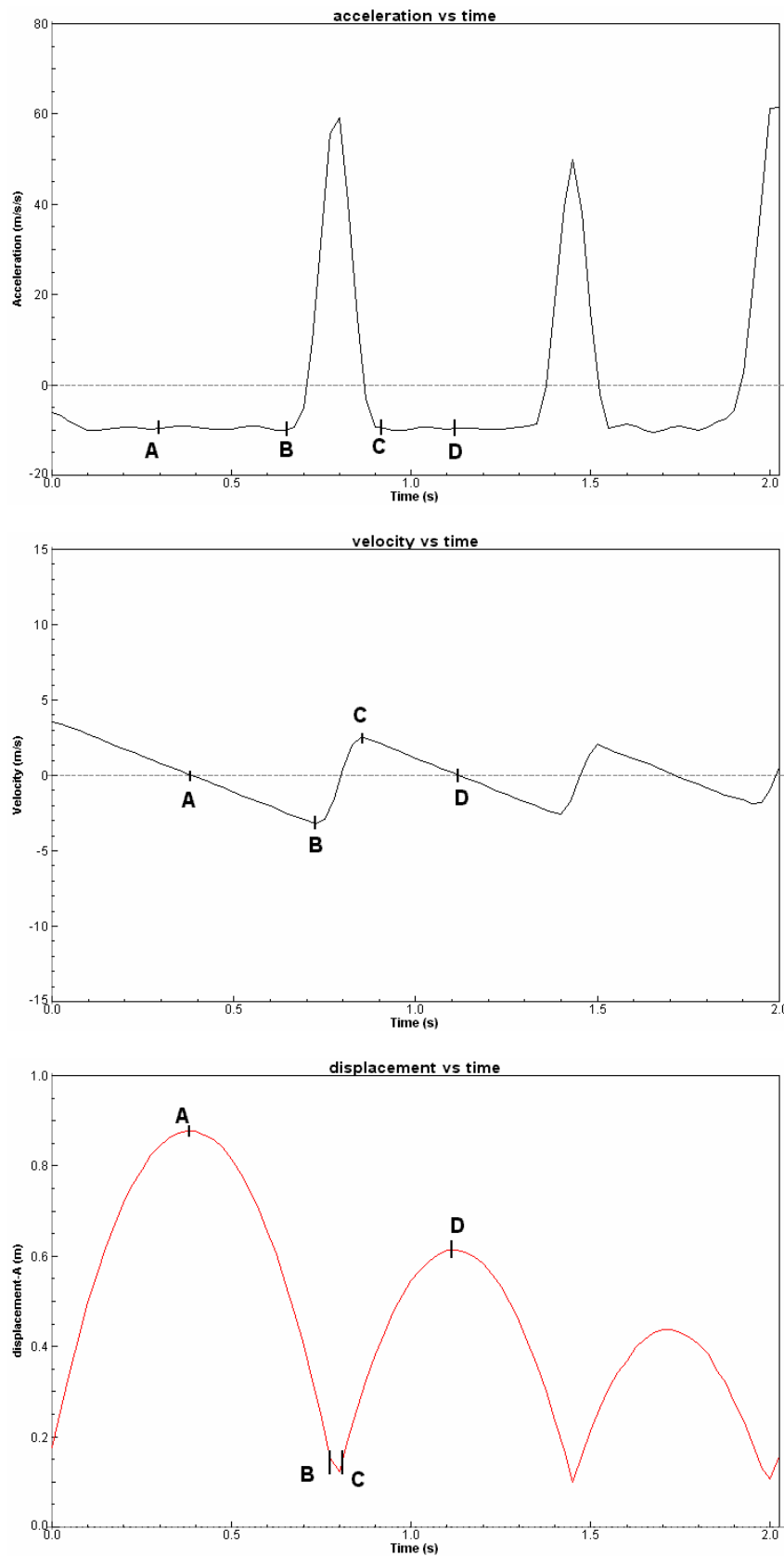
Set up the apparatus as shown in the diagram below.



#### Procedure

- Fix the Motion Detector at a height of about 1,8m above the floor, facing downwards.
- Hold the ball about 0.5m directly below the motion detector. Stand as far away as possible so that the motion detector does not detect your presence.
- Release the ball and simultaneously START collecting data. Make sure that the ball bounces directly below the sensor.
- Carry out the procedure a few times until you are satisfied with the graphs you obtain.

You should obtain graphs that are similar to the ones on the next page.



Work in small groups to answer the following questions.

- 1 Describe the motion of the ball once it left the hand.

.....

.....

- .....
- 2 Note that the upward direction is taken as positive. Look at the graphs above and describe the motion of the ball over the region AB.

.....

.....

.....

- 3 What happens to the ball during the very short interval BC?

.....

.....

.....

- 4 Describe the motion of the ball over the region CD.

.....

.....

.....

- 5 Point D on the graph represents a point during the ball's motion where it reaches its maximum height above the ground. Without looking at actual figures, can you describe the magnitude and direction of the velocity and acceleration of the ball at this point?

.....

.....



6

Now use the EXAMINE function point. Was your prediction Explain.



to determine the acceleration and velocity at this correct?

.....

.....

.....

7

By examining all the graphs, we can see that the bounce of the ball is getting smaller and smaller every time. Why is this so?

.....

.....

.....



## Activity 7

### Investigating the Conservation of Mechanical Energy

Name: \_\_\_\_\_

Grade: \_\_\_\_\_ Date: \_\_\_\_\_

Experiment file: energy.exp

When you have completed this activity, you should be able to:

- Explain the relationship between height above ground level and potential energy.
- Explain the relationship between velocity of the object and its kinetic energy.
- Use the generated graphs to show that mechanical energy is the same at all points during the motion of the object.

(Your teacher will assess whether you have achieved these criteria in the assessment tasks he/she sets.)

### Terminology

Kinetic Energy ( $E_k$ ):

The energy that a body possesses as a result of its motion.

Gravitational Potential Energy ( $E_p$ ):

The energy that a body possesses as a result of its position relative to a chosen reference level.

Mechanical Energy:

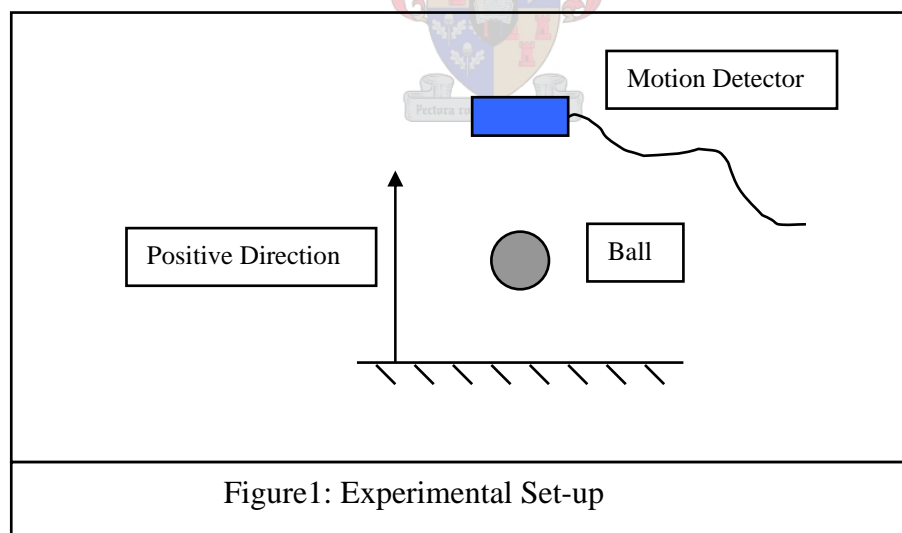
The sum of the potential and kinetic energy in a specific system.

Principle of conservation of Energy.

Energy cannot be created or destroyed, but it can be changed from one form into an equivalent amount of another.

### Part A: Experimental set-up

Set up the apparatus as shown in the diagram below:



## Procedure:

Open energy.exp file in the MPLI programme.

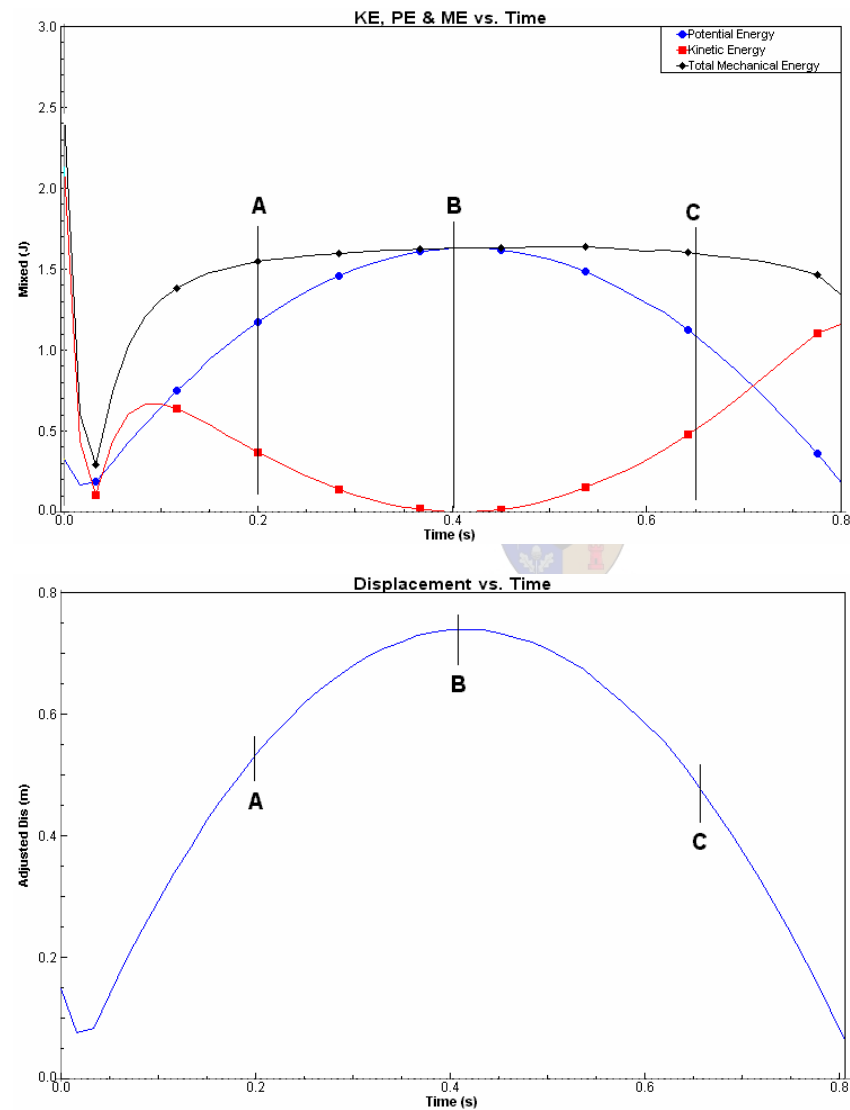
Stand as far as possible from the detector and hold the ball approximately 0,5m below the motion detector.

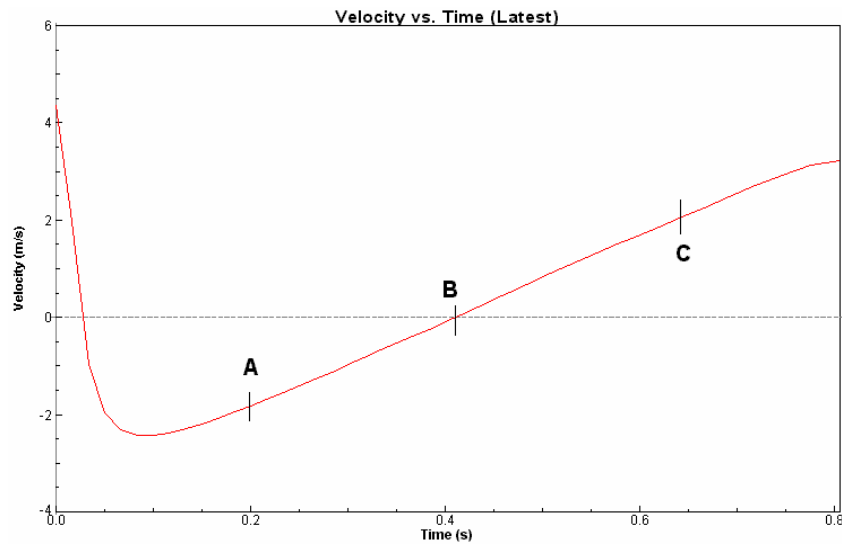
Simultaneously release the ball and click on the start icon to collect data.

If the results look reasonable, STORE DATA( run 2 = the first stored set of results. Otherwise repeat the experiment.

### Take note:

- Make sure that the motion detector is set up a 1,5m above the ground level.
- Hold the ball approximately 0.5m from the motion detector.
- Let the ball drop from your hands; don't throw it upwards.
- Let the ball hop a few times until you are satisfied with the shape of the graphs.
- For best results use a volleyball or a basketball.





Work in small groups to carry out the investigation.

### Analysis

Use your own results to answer the following questions.

Choose a section on your three graphs, which look similar to the above shown one. Explain briefly what the ball is doing at points A, B and C.

---



---



---

Look at the shape of your  $s/t$  and  $E_p/t$  graphs. Explain the relationship between these two graphs.

---



---

Look at the shape of your  $v/t$  and  $E_k/t$  graphs. Explain the relationship between these two graphs.

---



---

Activate the examine feature on the toolbar and examine the values of the Potential-, Kinetic- and Mechanical Energy at points A, B and C. Write down the values in the following table.



Points	Potential Energy	Kinetic Energy	Mechanical Energy
A			
B			
C			

What do you notice about the mechanical energy column?

---

What will the value of the Kinetic-, Potential- and Mechanical Energy be:

- a) When the ball strikes the ground? \_\_\_\_\_
- b) When the ball is midway between its highest and lowest point? \_\_\_\_\_
- c) When the ball is at its highest point above the ground level? \_\_\_\_\_



## VECTORS

### VECTORS

At the end of this section you will be able to:

1. know the difference between a vector and a scalar; ( 1 2 3 )
2. know how to indicate direction; ( 1 2 3 4 )
3. determine the resultant of two or more vectors; ( 1 2 3 4 5 6 )
4. resolve vectors into components. ( 1 2 )

### SCALARS & VECTORS

Scalar: A quantity that has only magnitude.

Vector: A quantity with both magnitude and direction (represented by an arrow).

Resultant: The single vector that will have the same effect as the original vectors together.

1

### SCALARS & VECTORS

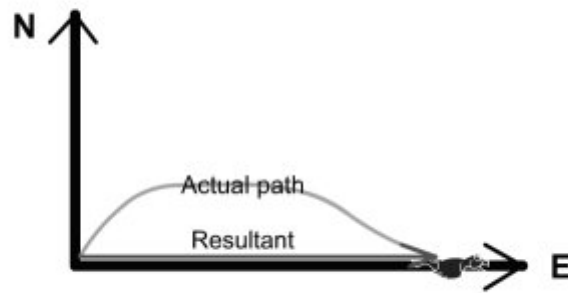
We will use displacement as an example of a vector.

Distance: The actual distance covered by an object.

Displacement: The magnitude and direction of a straight line drawn from the starting point to the end-point of motion.

2

# SCALARS & VECTORS



## Questions

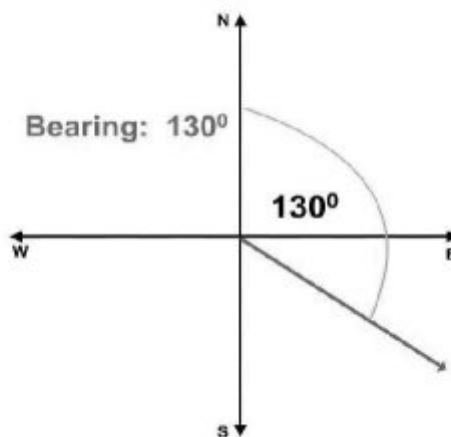
1. Define a scalar.
2. Define a vector.
3. What is the difference between distance and displacement?
4. What is a resultant?

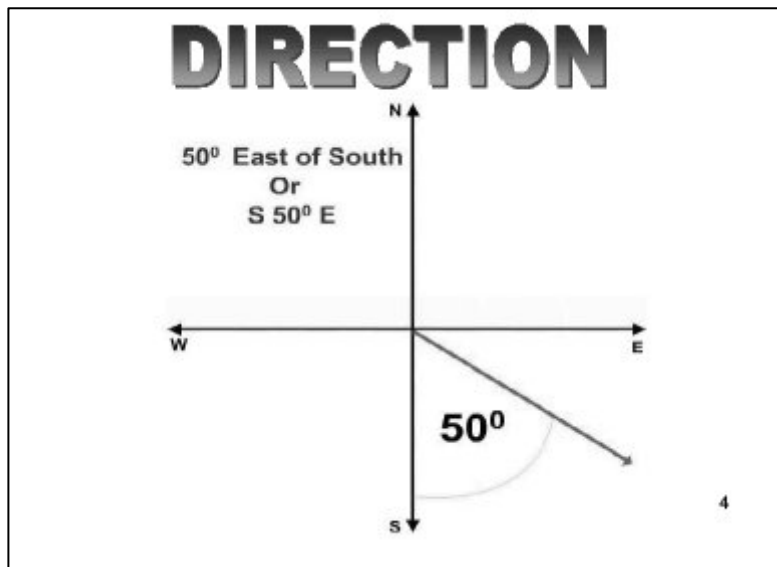
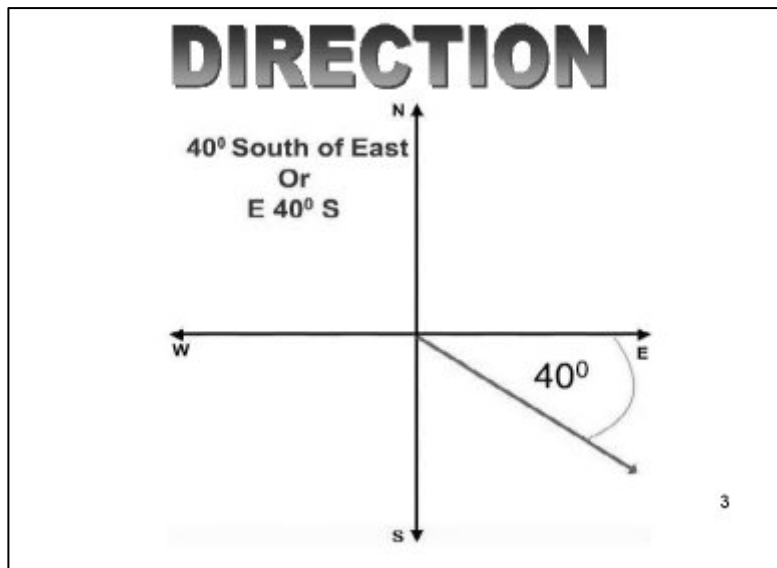
# DIRECTION

The following diagrams show us three ways of indicating direction.

1

# DIRECTION





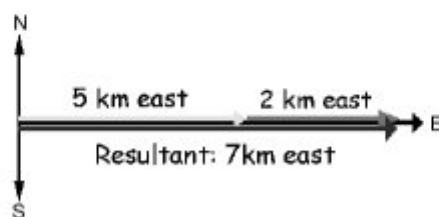
### Questions

1. Make a drawing to indicate a bearing of  $110^\circ$ .
2. What is meant by a direction of  $30^\circ$  east of south?

## DETERMINING RESULTANT

When vectors are acting in a straight line, they can simply be added to determine the resultant.

Displacements in the same direction :

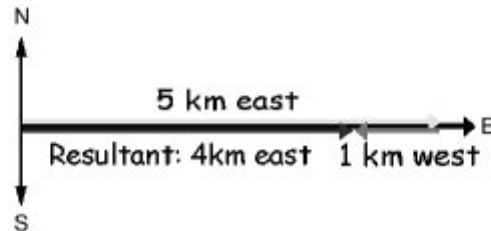




## DETERMINING RESULTANT

When vectors act in opposite direction in a straight line, they are added by awarding opposite signs to opposite directions when determining the resultant.

Displacements in opposite direction:



2

## DETERMINING RESULTANT

When vectors act at an angle with each other, we can determine the resultant with one of three methods:

1. Triangle method
2. Parallelogram method
3. The polygon method

3

## TRIANGLE METHOD

Triangle method:

Also called the "tail to head method". The magnitude and direction of the resultant is obtained by drawing a straight line from the tail of the first vector to the head of the last vector.

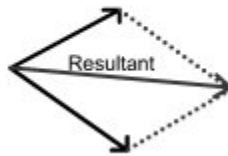


4

## PARALLELOGRAM METHOD

Parallelogram method:

Taking their magnitudes and directions into account, two vectors are drawn from the same point. The parallelogram is completed. The resultant is then the diagonal which is also drawn from the same point.

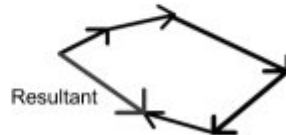


5

## POLYGON METHOD

Polygon method:

Vectors are added as in the triangle method, head to tail. There are now more than two vectors.



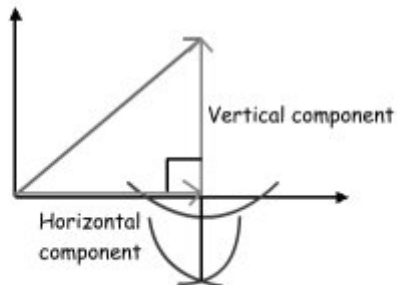
6

### Questions

1. How do we determine the resultant when vectors are acting in a straight line?
2. Name three ways to determine a resultant when vectors are at an angle with one another.

## RESOLVING VECTORS INTO COMPONENTS

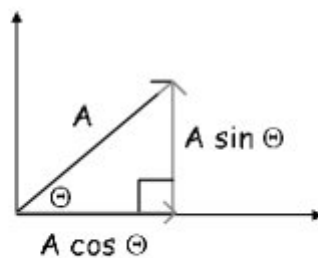
Graphically



1

## RESOLVING VECTORS INTO COMPONENTS

By Calculation



2

### Questions

1. A vector makes an angle of  $50^\circ$  with the vertical. Give expressions to calculate the vertical and horizontal components if the vector has a magnitude of 200.
2. Determine the vertical component of a vector with magnitude 50 on a bearing  $30^\circ$  graphically.

# FORCE

## FORCE

At the end of this section you will be able to:

1. understand the vector nature of force; ( 1 2 3 4 )
2. know what an equilibrant is; ( 1 2 3 4 )
3. know how to use the triangle method for three forces in equilibrium; ( 1 2 3 )
4. determine components of objects on slopes. ( 1 2 3 4 5 )

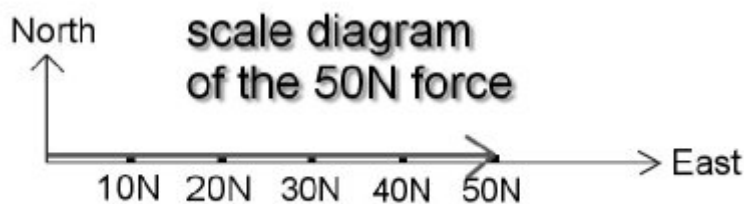
## VECTOR NATURE

Force is a vector. It therefore has magnitude and direction.

A force can be represented by an arrow with a certain length, pointing in a certain direction, e.g. if a cart is pulled towards the east with a force of 50N, it can be represented as follows.

1

## VECTOR NATURE



2

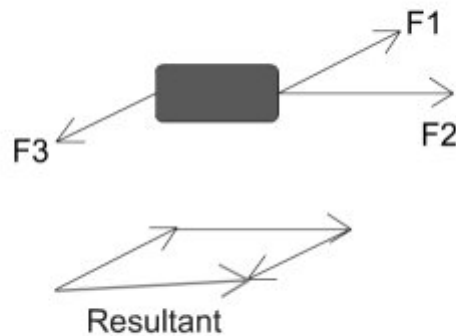
## VECTOR NATURE

It could happen that there would be more than one force acting on an object.

In such a case the resultant can be determined by vector addition. The following slide gives an example.

3

## VECTOR NATURE



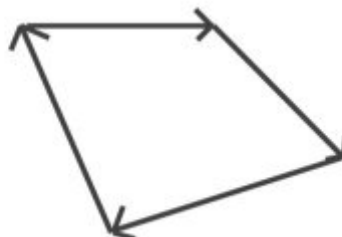
4

### Questions

1. Why is force a vector?
2. How can we determine the resultant of a number of forces acting at an angle with one another?

## EQUILIBRANT

When a number of vectors add up to a zero resultant, we say that the forces are in equilibrium. The following image shows a vector diagram for four forces in equilibrium. Note that arrowheads don't meet anywhere.



1

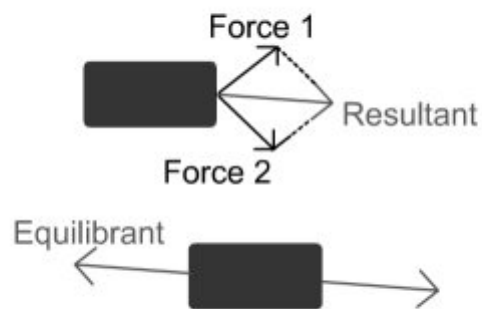
# EQUILIBRANT

Equilibrant:

The single force that keeps the other forces that act on an object in equilibrium. It is equal in magnitude to the resultant but acts in opposite direction.

2

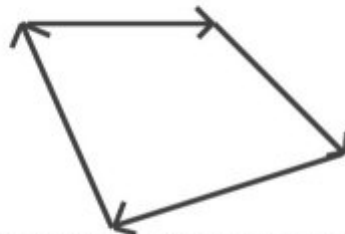
# EQUILIBRANT



3

# EQUILIBRANT

Remember the following diagram?



Each of the vectors in the polygon of forces above, is the equilibrant of the resultant of the other three. This is true because each one is needed to keep the other three in equilibrium.

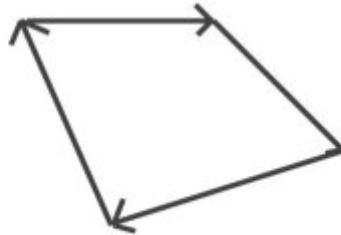
4

### Questions

1. What is meant by equilibrium?
2. Define the equilibrant.
3. Three forces have a resultant of 30N east. What is the magnitude and direction of the equilibrant?

### TRIANGLE RULE

The following image reminds us that forces in equilibrium (i.e. there is a zero resultant) lead to a closed vector diagram when added.



1

### TRIANGLE RULE

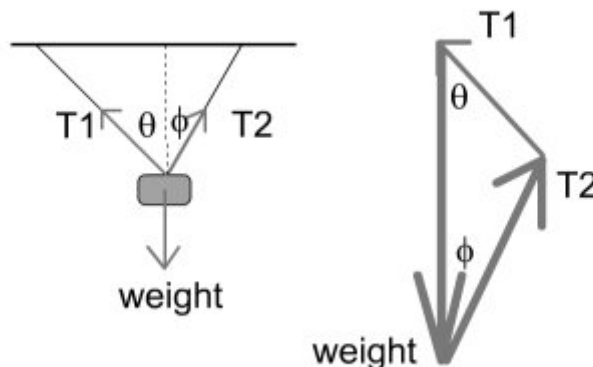
If we had only three forces acting on an object with a zero resultant (i.e. in equilibrium), adding them should yield a closed geometrical figure with three sides. This leads to the triangle rule.

Triangle Rule for three forces in equilibrium:

When three forces acting at the same point are in equilibrium, they can be represented in magnitude and direction by the sides of a triangle taken in order.

2

### TRIANGLE RULE



3

### Questions

1. Define the triangle rule for three forces in equilibrium.
2. Criticize the following statement: The triangle rule for three forces in equilibrium is used to determine the resultant of two forces.

### OBJECT ON A SLOPE

In the first section it was shown how vectors can be resolved into components.

Resolving forces into components can be useful when wanting to solve force-related problems. One example of this is solving problems regarding an object on a slope.

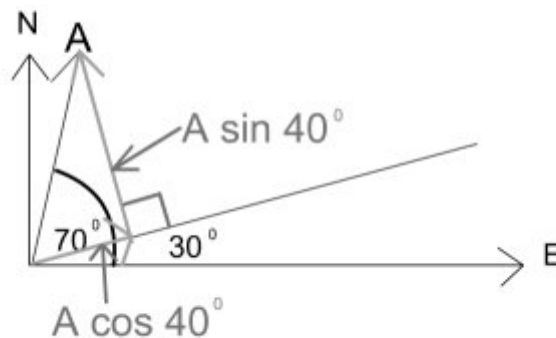
1

### OBJECT ON A SLOPE

A component of a vector (in this case a force) can be calculated in any direction. The following example shows the diagram for the component of Force A parallel to and perpendicular to the direction  $30^\circ$  North of East.

2

### OBJECT ON A SLOPE



3

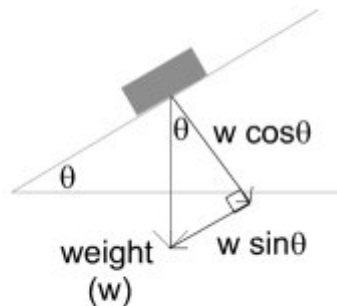


## OBJECT ON A SLOPE

When solving problems on objects on slopes, it is often necessary to calculate the components of the weight of the object parallel to and perpendicular to the slope. The following example shows how this can be done.

4

## OBJECT ON A SLOPE



5

### Questions

1. An object of weight 30 N is resting on a slope of  $40^\circ$  with the horizontal. Draw a vector diagram to show the components of the weight, parallel and perpendicular to the slope.
2. Which component in question 1 is equal to the frictional force between the object and the slope?

# VELOCITY & ACCELERATION

## VELOCITY & ACCELERATION

At the end of this section you will be able to:

1. distinguish between definitions regarding velocity, speed and acceleration; ( 1 2 )
2. solve the following types of problems:
  - determining resultant velocities ( 1 2 3 4 5 )
  - determining a velocity component of a resultant ( 1 2 )
  - river problems ( 1 2 3 )
  - ticker tape problems. ( 1 2 3 4 5 6 )

## DEFINITIONS

Average Speed:

The total distance traversed divided by the total time.

Instantaneous Speed:

The true speed at a specific point in time.

1

## DEFINITIONS

Average Velocity :

The rate of change of displacement.

Instantaneous Velocity:

The true velocity at a specific point in time.

Average Acceleration:

The rate of change in velocity.

2

### Questions

1. Give definitions for:
  - 1.1 Average speed
  - 1.2 Average velocity
  - 1.3 Average acceleration
  - 1.4 Instantaneous speed
  - 1.5 Instantaneous velocity

## RESULTANT VELOCITIES

An aeroplane flies at 500 km/h on a bearing  $30^\circ$ . A wind blowing at 80 km/h due east blows the plane off course. Determine the resultant velocity of the plane.

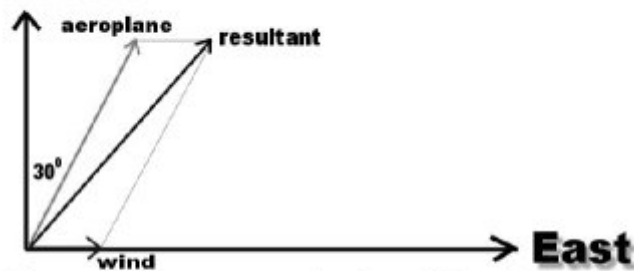
When solving a problem of the type given above, it is necessary to make a rough sketch first. The following vector diagram shows how this can be done.

1



## RESULTANT VELOCITIES

**North**



The solution can now be found by either making a scale drawing or doing a calculation. You should find the following answer:

$$V_R = 544,43 \text{ km/h; Bearing } 37,31^\circ$$

2

## RESULTANT VELOCITIES

Determine the resultant velocity if a girl walks at 2m/s North for 3 minutes and thereafter at 3m/s East for 4 minutes.

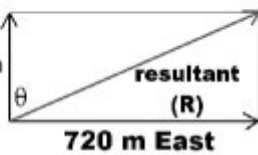
**Solution:** First calculate the resultant displacement for each leg of the trip and thereafter the resultant displacement for the whole trip.

$$\begin{aligned}
 s_1 &= v_1 t_1 & s_2 &= v_2 t_2 \\
 &= 2 \times 180 & &= 3 \times 240 \\
 &= 360\text{m North} & &= 720\text{m East}
 \end{aligned}$$

3

## RESULTANT VELOCITIES

Calculate the resultant displacement and velocity as follows:



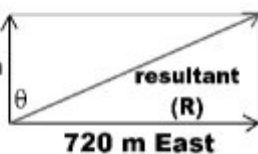
$$R = \sqrt{360^2 + 720^2}$$

$$\begin{aligned}
 \text{velocity}_{\text{resultant}} &= \frac{\text{resultant displacement}}{\text{total time}} \\
 &= \frac{\sqrt{360^2 + 720^2}}{420} \\
 &= 1,92 \text{ m/s}
 \end{aligned}$$

4

## RESULTANT VELOCITIES

Calculate the bearing as follows:



$$\begin{aligned}
 \tan \theta &= \frac{720}{360} \\
 \theta &= 63,43^\circ
 \end{aligned}$$

Resultant velocity = 1,92 m/s; Bearing  $63,43^\circ$

5

### Questions

1. How does one calculate the resultant velocity of a number of velocities that do not occur simultaneously? (Hint: Look at the solution of the second problem.)
2. What do you need to do before starting calculations when determining resultant velocities?

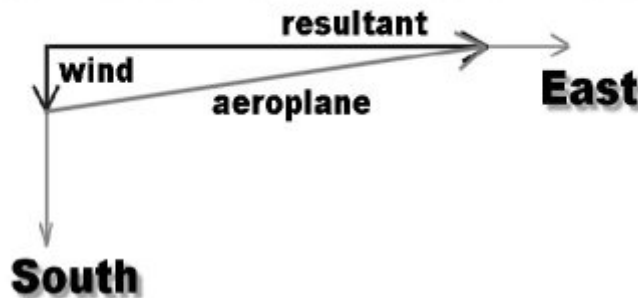
### VELOCITY COMPONENT

An aeroplane needs to fly to a destination 1500 km due East in two hours. A wind of 80km/h is blowing due South. At what velocity should the aeroplane fly to reach the destination on time?

If this problem is compared to the first aeroplane problem, one should take note that the resultant is given in this case. The question is to calculate the component that together with the wind would yield a resultant of 750 km/h.

1

### VELOCITY COMPONENT



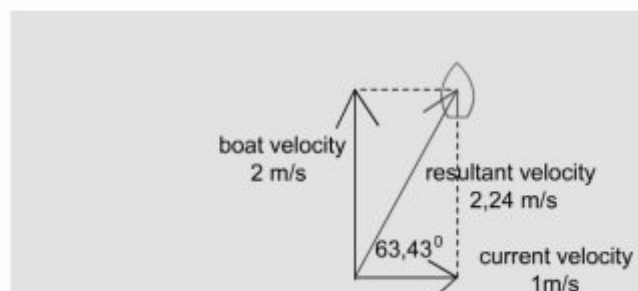
The solution can now be found by either making a scale drawing or doing a calculation. You should find the following answer:

velocity = 754,25 km/h; Bearing  $83,91^\circ$

2

### RIVER PROBLEMS

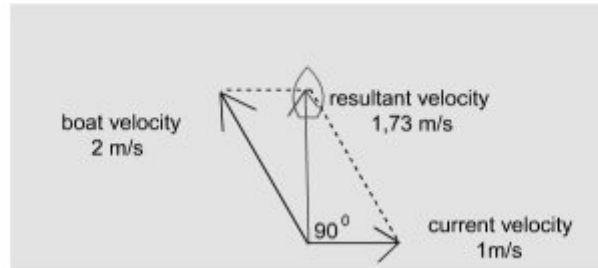
A boat travels in still water at 2 m/s. It is rowed across a river that flows at 1m/s. Determine the resultant velocity of the boat.



1

## RIVER PROBLEMS

A boat travels in still water at 2 m/s. The boatsman wants to reach a point on the other bank directly opposite from where he started out. Determine the resultant velocity if the river flows at 1 m/s.



2

## RIVER PROBLEMS

If one wants to calculate the time it would take to reach the opposite bank, one would have to make sure that the displacement which is being divided by the velocity has the same direction as that velocity. In other words vectors have to be in the same direction.

In this case, if the river was 50 m wide, one would divide 50 m by 1,73 m/s as this velocity is in the same direction as the displacement. The answer would be 28,9 s.

3

### Questions

1. Distinguish between two types of river problems.
2. If one wants to calculate the time it takes to cross the river by dividing the displacement by the velocity, what must be the same for those two vectors?

## TICKER TAPES

The following two animations show the difference between a ticker tape from a constant non zero velocity and one from constant non zero acceleration.



## TICKER TAPES

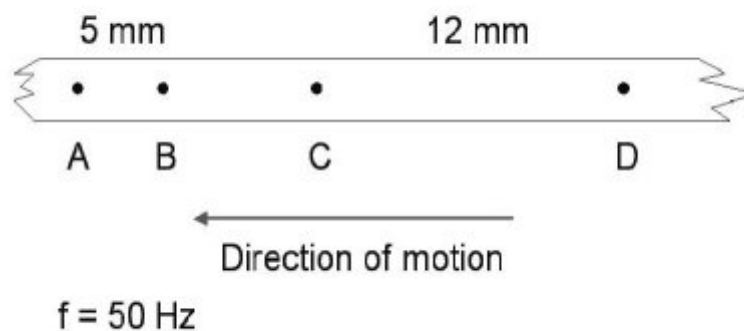
The first animation showed a constant velocity. This could be identified by equal spaces between the dots on the tape. In the second animation one could see the spaces increasing by the same amount for each successive time interval. This is typical of a constant acceleration.

Let's now consider calculating an acceleration from a given ticker tape.

2

## TICKER TAPES

The following information is given:



3

## TICKER TAPES

To calculate acceleration one needs to find two velocities and then divide the difference between them by the time it takes for the difference to occur.

In this example we will find the two velocities by calculating the average velocities between AB and CD.

4

## TICKER TAPES

Average velocity can be calculated by dividing the total displacement by the total time.

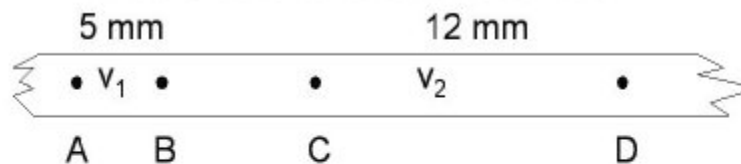
We then need to subtract these two velocities and divide the answer by the total time between them.

To obtain the time between the velocities, we need to remember that average velocity is equal to instantaneous velocity in the middle of the time interval.

The time between the two velocities is therefore from the middle of AB to the middle of CD.

5

## TICKER TAPES



$$V_1 = \frac{\text{total displacement}}{\text{total time}} = \frac{0,005}{0,02} = 0,25 \text{ m/s}$$

$$V_2 = \frac{\text{total displacement}}{\text{total time}} = \frac{0,012}{0,02} = 0,60 \text{ m/s}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{0,60 - 0,25}{0,04} = 8,75 \text{ m/s}^2$$

6

### Questions

1. Describe the difference between the ticker tape for constant velocity and the one for constant acceleration.
2. Why must the direction of motion be given when the acceleration of an object is calculated from a ticker tape?



# GRAPHS

## GRAPHS

At the end of this section you will be able to:

1. know how the different graphs are related; (1 2 3 4 )
2. know how to draw graphs for an object moving at a constant velocity; (1 2 3 4 )
3. know how to draw graphs for an object moving at a constant acceleration; (1 2 3 )
4. do examples on drawing graphs. ( 1 2 3 4 5 6 7 8 )

## RELATIONSHIP BETWEEN GRAPHS

You have to be able to draw displacement-time, velocity-time, acceleration-time, distance-time and speed-time graphs. Take note that some of these represent graphs of vectors vs time and others are scalars.

1

## RELATIONSHIP BETWEEN GRAPHS

To make it easier to draw one type of graph when another is given (e.g. draw displacement-time when velocity-time is given), the following definitions need to be remembered.

$$v = \frac{\Delta s}{\Delta t} \quad a = \frac{\Delta v}{\Delta t}$$

These definitions are the same for vectors or scalars.

2

### RELATIONSHIP BETWEEN GRAPHS

Let's consider  $v = \frac{\Delta s}{\Delta t}$  :

$v$  is the value of the velocity.

$$\begin{aligned} \frac{\Delta s}{\Delta t} &= \frac{\text{a change in displacement}}{\text{a change in time}} \\ &= \frac{\text{a vertical change}}{\text{a horizontal change}} \text{ of the } s \text{ vs } t \text{ graph} \\ &= \text{the gradient of the } s \text{ vs } t \text{ graph} \end{aligned}$$

3

### RELATIONSHIP BETWEEN GRAPHS

This means that the value of the velocity time-graph is equal to the gradient of the displacement-time graph. The same would be true for the relationship between speed-time and distance-time.

Similarly for  $a = \frac{\Delta v}{\Delta t}$ , the value of the acceleration is equal to the gradient of the velocity-time graph.

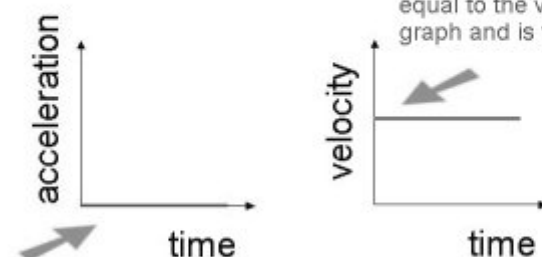
4

### Questions

1. What is the relationship between the velocity value on the velocity-time graph and the gradient of the displacement-time graph?
2. What is the relationship between the gradient of the velocity-time graph and the acceleration value on the acceleration-time graph?

### CONSTANT VELOCITY

Draw acceleration-time, velocity-time and displacement-time graphs for an object moving at a positive, constant velocity.

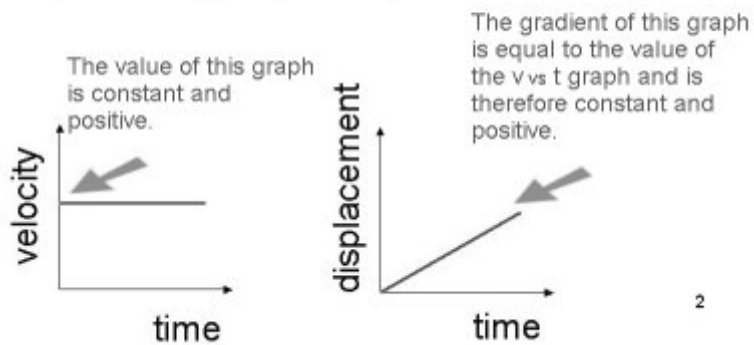


As the velocity is constant, the value of the acceleration is 0.

1

## CONSTANT VELOCITY

This slide shows the relationship between the velocity-time and displacement-time graphs for an object moving at a positive, constant velocity.



## CONSTANT VELOCITY

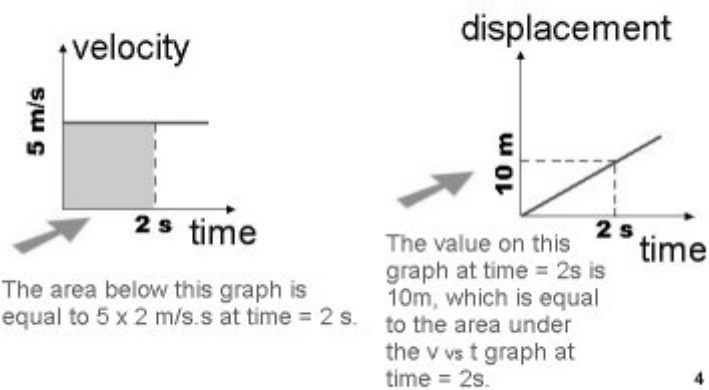
The area below the velocity-time graph at certain time is equal to the value of the displacement-time graph at that time.

If an object moves at 5 m/s for 2 seconds, its displacement can be calculated with  $s = vt$ . This yields an answer of 10m.

The next slide graphically represents the information in the example above .

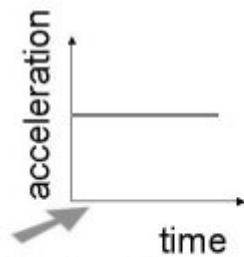
3

## CONSTANT VELOCITY

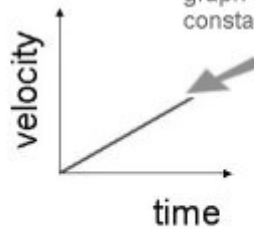


## CONSTANT ACCELERATION

Draw acceleration-time, velocity-time and displacement-time graphs for an object moving at a positive, constant acceleration.



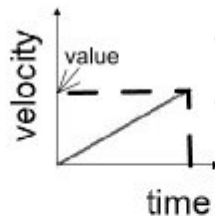
The value of the acceleration is constant and positive.



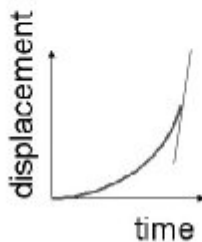
The gradient of this graph is equal to the value of the  $a$  vs  $t$  graph and is therefore constant and positive.

1

## CONSTANT ACCELERATION



The value of the velocity becomes greater positive as the time increases.



The gradient of the displacement-time graph becomes greater positive as the time increases.

2

## CONSTANT ACCELERATION

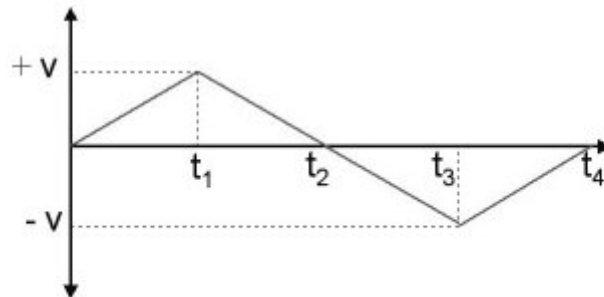
Take note that just as with constant velocity, the area below the velocity-time graph is still equal to the displacement at that time. Similarly, the area below the acceleration-time graph is equal to the velocity at that time.

3

**EXAMPLE**

Draw the following graphs from the given velocity-time graph.

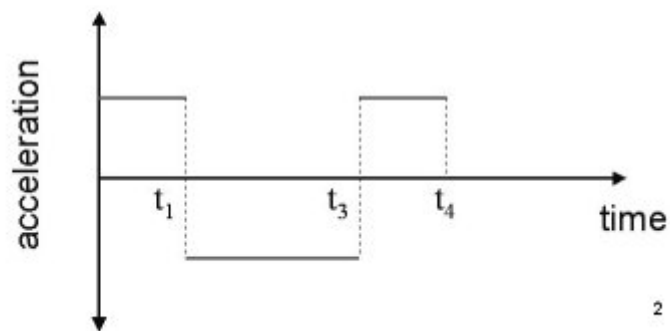
acceleration-time, displacement-time, speed-time, distance-time



1

**EXAMPLE**

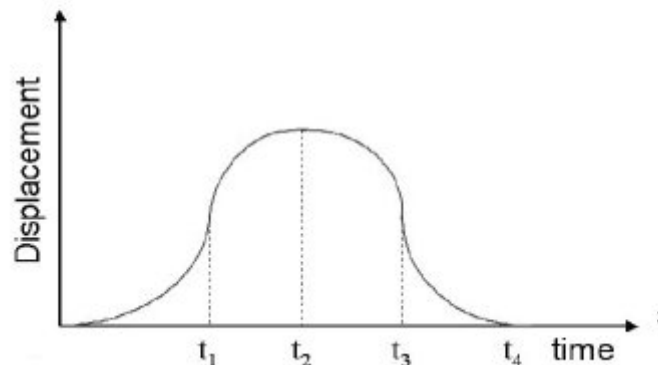
Remember that the value of the acceleration-time graph is equal to the gradient of the velocity-time graph.



2

**EXAMPLE**

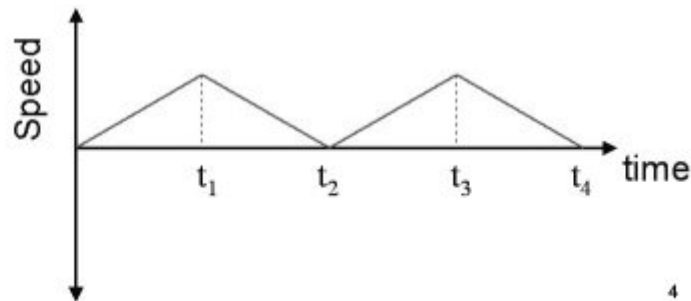
Remember that the value of the velocity-time graph is equal to the gradient of the displacement-time graph.



3

## EXAMPLE

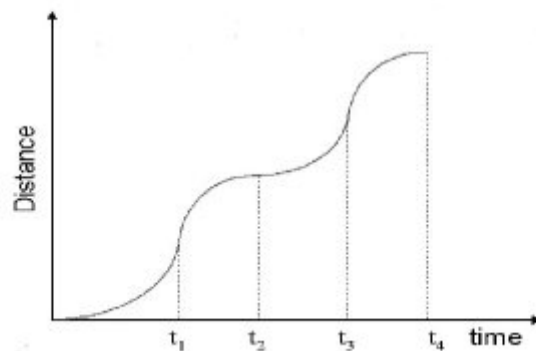
Remember that speed is a scalar and can therefore not be negative. All the negative sections of the velocity-time graph become positive here.



4

## EXAMPLE

Remember that the value of the speed-time graph is equal to the gradient of the distance-time graph. The distance-time graph can therefore not have a negative gradient.

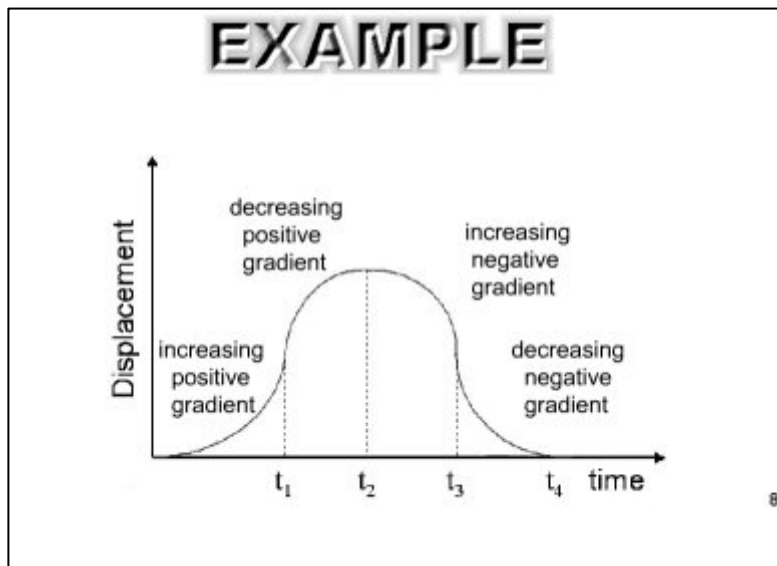
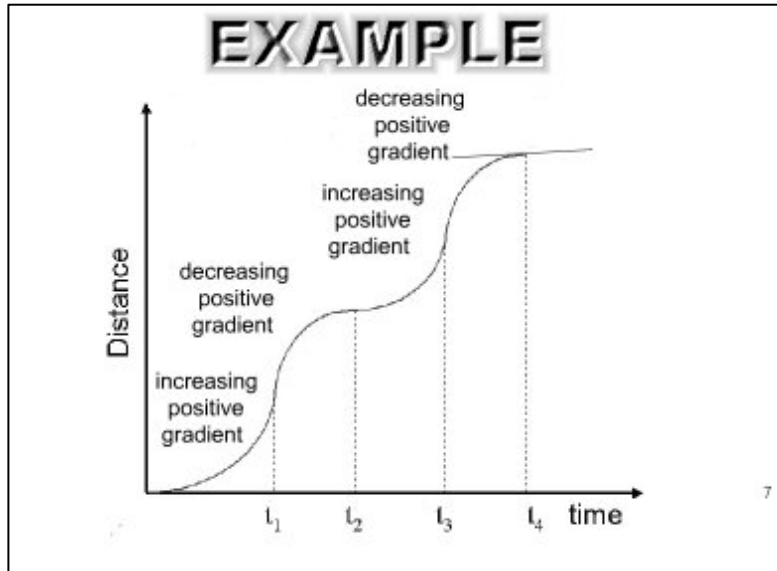


5

## EXAMPLE

The following two slides have animations illustrating the difference between the different types of changing gradients. This is especially necessary to know when drawing displacement-time and distance-time graphs.

6



### Questions

1. Draw curves that represent:
  - 1.1 A constant negative gradient
  - 1.2 An increasing negative gradient
  - 1.3 A constant positive gradient
  - 1.4 An increasing positive gradient.

# EQUATIONS OF MOTION

## EQUATIONS OF MOTION

At the end of this section you will be able to:

1. know the different equations of motion; ( 1 2 )
2. know the relationship between equations of motion for constant velocity and equations of motion for constant acceleration; (1 2 )
3. recognise and solve problems relating to equations of motion. ( 1 2 )

$t = ?$

$a = ?$

## EQUATIONS

You already know that we use  $s = vt$  for objects that move at a constant velocity. What are we going to use if an object moves at a constant acceleration?

Just as  $s = vt$  is an equation of motion for constant velocity, we have equations of motion for constant acceleration. The next slide introduces you to these equations.

1

## EQUATIONS

$s$  = displacement

$u$  = initial velocity

$v$  = final velocity

$t$  = time

$a$  = acceleration

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$s = ut + \frac{1}{2}at^2$$

$$s = \frac{u + v}{2}t$$

2



### Questions

1. What does each of the following symbols that are used in equations of motion represent?  $a$ ,  $s$ ,  $t$ ,  $u$ ,  $v$
2. Write down four equations of motion.

#### CONSTANT $V$ vs CONSTANT $a$

What happens to these equations if the acceleration equals 0?

$$\begin{aligned}
 v &= u + at \\
 &= u + 0t \\
 &= u \\
 v^2 &= u^2 + 2as \\
 &= u^2 + 2 \cdot 0 \cdot s \\
 &= u^2 \\
 \therefore v &= u
 \end{aligned}$$

1

#### CONSTANT $V$ vs CONSTANT $a$

$$\begin{aligned}
 s &= ut + \frac{1}{2}at^2 & s &= \frac{u+v}{2}t \\
 &= ut + \frac{1}{2} \cdot 0 \cdot t^2 & &= \frac{u+u}{2}t \\
 &= ut & &= \frac{2u}{2}t \\
 & & &= ut
 \end{aligned}$$

We see that each equation reduces to either  $s = ut$  or  $u = v$ . These are, of course, the equations we had for constant velocity. This makes sense as a zero acceleration implies a constant velocity.

2

**EXAMPLE**

A car travelling at 54km/h, brakes at an acceleration of  $2\text{m/s}^2$  opposite to its direction of motion. How far does the car travel from the moment it starts applying the brakes until it stops?

1

**EXAMPLE**

Solution

$$u = 15\text{m/s}; v = 0; a = -2\text{m/s}^2; s = ?$$

$$v^2 = u^2 + 2as$$

$$0 = 15^2 + 2(-2)s$$

$$s = 56,25\text{m}$$

2

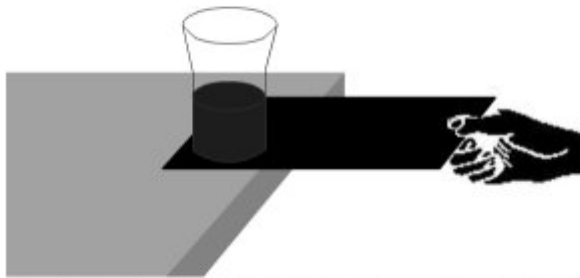
## NEWTON'S LAWS

### NEWTON'S LAWS

At the end of this section you will be able to:

1. know and apply Newton's First Law; ( 1 2 3 )
2. know and apply Newton's Second Law; ( 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 )
3. know and apply Newton's Third Law; ( 1 2 3 )
4. know and apply Newton's Universal Gravitational Law ( 1 2 3 4 5 6 7 ) and understand vertical projectile motion. ( 1 2 3 4 5 6 7 8 )

### NEWTON'S FIRST LAW



In the animation above, the glass is stationary when the paper is pulled quickly, but moves with the paper if it is pulled slowly.

1

### NEWTON'S FIRST LAW

When the sheet of paper is being pulled quickly, the glass remains at rest as it does not experience a resultant force to bring it into motion.

When the paper is being pulled slowly, the frictional force between the paper and glass is strong enough to bring the glass into motion.

We notice that the glass tends to stay at rest, unless forced to move.

This property of matter which maintains an object's state of rest or its constant motion in a straight line, is called inertia.

2

## NEWTON'S FIRST LAW

The concept of inertia is embodied in Newton's First Law of Motion.

*A body will remain at rest or continue with uniform velocity in a straight line, unless it is acted upon by an external resultant force.*

The mass of an object serves as a quantitative measure of its inertia.

3

### Questions

1. What is inertia?
2. Formulate Newton's First Law.
3. How can inertia be measured quantitatively?
4. Is Newton's First law only applicable to objects at rest?

## NEWTON'S SECOND LAW

Newton's First Law tells us that we need a resultant force to change an object's state of motion.

Newton's Second Law addresses the issue of how a resultant force will affect the object's motion.

1

## NEWTON'S SECOND LAW

To investigate the effect of a resultant force on a mass, the following needs to be done:

1. Investigate the effect of a constant resultant force on a constant mass.
2. Investigate the effect of changing the resultant force on a constant mass.
3. Investigating the effect of changing the mass while the resultant force is kept constant.

2

## NEWTON'S SECOND LAW

These relationships can be investigated using a ticker timer, trolley and weights. Investigation yields the following results:

1. A constant resultant force produces a constant acceleration on a constant mass.
2. The magnitude of the resultant force is directly proportional to the acceleration it produces for a given mass.
3. For a constant resultant force, the acceleration of an object is inversely proportional to its inertial mass.

3

## NEWTON'S SECOND LAW

Mathematically:

$$F \propto a$$

and

$$\frac{1}{m} \propto a$$

Therefore:

$$F \times \frac{1}{m} \propto a$$

or

$$F \propto ma$$

To make the proportionality an equation, we need a proportionality constant,  $k$ . The equation then becomes  $F = kma$ .

If we choose 1N to be the force if a mass of 1kg is accelerated by  $1\text{m/s}^2$ ,  $k$  becomes 1 and the equation is then  $F = ma$ .

4

## NEWTON'S SECOND LAW

To fully understand Newton's Second Law, we need to look at momentum first.

Momentum is a measure of the quantity of motion of an object. This is calculated by the product of the mass and the velocity.

$$p = mv$$

This is a vector quantity, as velocity has direction.

When the momentum of a body changes, it is calculated by  $\Delta p = \Delta mv$ .

5

## NEWTON'S SECOND LAW

If this change in momentum is caused by a change in velocity only, the equation becomes:  $\Delta p = m\Delta v$ .

This change in momentum is a vector quantity.

Consider Newton's Second Law Mathematically:

$$F = ma$$

$$\text{But } m\Delta v = \Delta p$$

$$F = m \frac{\Delta v}{\Delta t}$$

Therefore :

$$F = \frac{\Delta p}{\Delta t}$$

6

## NEWTON'S SECOND LAW

Putting Newton's Second Law into words therefore becomes:

*Force is directly proportional to the rate of change in momentum and the change in momentum is in the direction of the force.*

Let's look at an example of how Newton's Second Law and change in momentum operate together.

7

### Questions

1. Formulate Newton's Second Law.
2. What is momentum?
3. What is the relationship between Newton's Second Law and change in momentum?

## NEWTON'S SECOND LAW

Imagine a ball being bounced off a wall.  
Choose motion towards the right as positive.



$$V_1 = 3\text{m/s}$$

$$V_2 = -2\text{m/s}$$

$$\begin{aligned}\Delta p &= mv - mu \\ &= m(-2 - 3) \\ &= -5m\end{aligned}$$

8

## NEWTON'S SECOND LAW

The change in momentum in the previous slide is therefore negative. As the force that caused this change in momentum is in the direction of the change in momentum, it is also negative. This force is the force that the wall exerts on the ball.

9

## NEWTON'S SECOND LAW

Remember that in  $F = ma$ ,  $F$  is always the resultant force acting on an object.



Calculate the tension in the cord between the weight and the trolley.

10

## NEWTON'S SECOND LAW

The whole system (trolley and weight) is accelerated by the 10N weight. (The weights of the ropes and the friction in the pulley can be neglected.)

The acceleration of the system can therefore be calculated by Newton II.

$$\begin{aligned}
 a &= \frac{F}{m} \\
 &= \frac{10}{5} \\
 &= 2 \text{ m/s}^2
 \end{aligned}$$

11

## NEWTON'S SECOND LAW



The tension in the string is the same everywhere.  
The pulley just changes the direction.

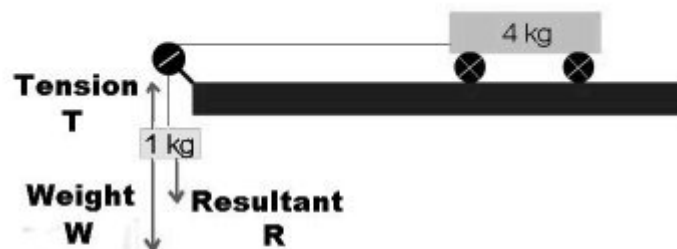
We can view the tension in the cord in one of two ways:

1. The cord supports the 1kg weight and keeps it from going into free fall.
2. The cord accelerates the 4 kg trolley.

12

## NEWTON'S SECOND LAW

1

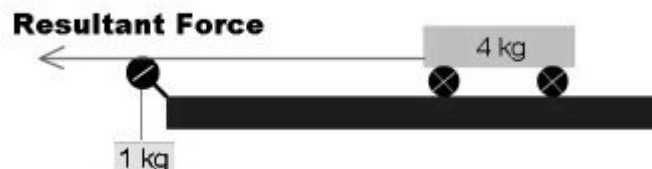


$$\begin{aligned}
 R &= W - T \\
 \therefore T &= W - R \\
 &= mg - ma \\
 &= 1(10 - 2) \\
 &= 8\text{N}
 \end{aligned}$$

13

## NEWTON'S SECOND LAW

2



According to Newton II, Resultant force =  $ma$

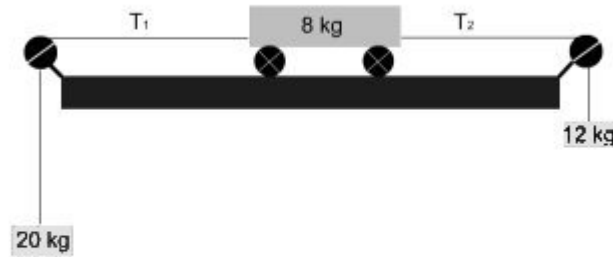
$$\begin{aligned}
 F &= ma \\
 &= 4 \times 2 \\
 &= 8\text{N}
 \end{aligned}$$

The same as in the  
previous slide!!

14



## NEWTON'S SECOND LAW



Calculate the tensions,  $T_1$  and  $T_2$ . Friction and masses of cords can be neglected.

15

## NEWTON'S SECOND LAW

The whole system is being accelerated by the resultant force of 80N ( $200\text{N} - 120\text{N}$ ).

This resultant force is accelerating all of the mass.

Newton II states that:

$$\begin{aligned} a &= \frac{F}{m} \\ &= \frac{80}{40} \\ &= 2\text{m/s}^2 \end{aligned}$$

16

## NEWTON'S SECOND LAW

$T_1$  can be viewed as keeping the 20 kg mass from going into free fall.

$$\begin{aligned} R &= W - T_1 \\ T_1 &= W - R \\ &= 200 - 40 \\ &= 160\text{N} \end{aligned}$$

17

## NEWTON'S SECOND LAW

$T_2$  can be viewed as accelerating the 12 kg mass upward. It also has to support the 12kg mass.

$$\begin{aligned} R &= T_2 - W \\ T_2 &= W + R \\ &= 120 + 24 \\ &= 144\text{N} \end{aligned}$$

18

## NEWTON'S THIRD LAW

Newton's Third Law describes the relationship between the forces that two objects exert on each other.



Each ball exerts an equal force on the other ball in the opposite direction.

1

## NEWTON'S THIRD LAW

Newton's Third Law: *If an object A exerts a force on object B, then B will exert an equal but opposite force on A.*

Take note that the two forces act on different objects. Newton III does not describe the forces on an object. It describes the interaction between objects.

Criticise the following statement: **A boy pushes against a heavy crate but can't move it. This is due to Newton's Third Law that states that the crate will push back just as hard as the boy, therefore causing a zero resultant.**

2

## NEWTON'S THIRD LAW

This statement is false. Newton's Third Law cannot be used to determine whether there is a resultant force or not.

To determine if an object experiences a resultant force one has to consider all the forces acting on that single object.

Newton III does not address the forces working on a single object. It describes the forces exerted by different objects on each other. The crate is not moving because the boy is not pushing hard enough to overcome the frictional force between <sup>3</sup> the crate and the floor.

### Questions

1. Formulate Newton's Third Law.
2. Can Newton's Third Law be used to predict the motion of an object? Explain.

## NEWTON'S LAW OF UNIVERSAL GRAVITATION

*Free fall: A unimpeded fall where only gravitational force acts on an object.*

*Terminal velocity (during free fall): The velocity an object has when the upward air resistance is equal to the earth's downward attracting force.*

*Gravitational acceleration (g): The acceleration of an object in earth's gravitational field.*

1

## NEWTON'S LAW OF UNIVERSAL GRAVITATION

The force of attraction between any two masses in the universe is called gravitation.

Gravitational force is directly proportional to the product of the masses and inversely proportional to the square of the distance from earth's centre.

Symbolically:  $F \propto m_1 \times m_2$

$$F \propto \frac{1}{r^2}$$

2

**NEWTON'S LAW OF UNIVERSAL GRAVITATION**

*Every particle in the universe exerts a force of gravitational attraction on every other particle. The force between the two particles is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.*

Mathematically:  $F = G \frac{m_1 \times m_2}{r^2}$

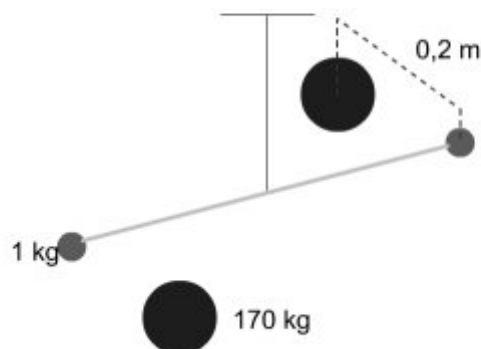
G is the universal gravitational constant:

$$G = 6,67 \times 10^{-11} \text{ N.m}^2.\text{kg}^{-2}$$

3

**NEWTON'S LAW OF UNIVERSAL GRAVITATION**

The value of G was determined by Lord Cavendish using an apparatus that functioned as shown in the next animation.



4

**NEWTON'S LAW OF UNIVERSAL GRAVITATION**

The value of g varies over earth's surface. At the equator it is less and at the poles it is more.  $9,8 \text{ m/s}^2$  is usually used. You may use  $10 \text{ m/s}^2$  unless stated otherwise in a problem.

The value of g is independent of the mass of the object in earth's gravitational field. This is shown mathematically in the next slide.

5

**NEWTON'S LAW OF UNIVERSAL GRAVITATION**

The force between an object and earth is given by:

$$F = G \frac{M \times m}{r^2}$$

According to Newton II:

$$F = mg$$

$$\text{Therefore : } mg = G \frac{M \times m}{r^2}$$

$$g = G \frac{M}{r^2}$$

6

**NEWTON'S LAW OF UNIVERSAL GRAVITATION**

The mathematical result in the previous slide shows that the mass of the object cancels out of the equation.

We have therefore shown that  $g$  is not dependent on the mass of the object, but only on the distance above the centre point of earth.

7

**Questions**

1. What is gravitation?
2. Formulate Newton's Law of Universal Gravitation.
3. Does the acceleration that an object experiences in earth's gravitational field, depend on its own mass? Explain.

**VERTICAL PROJECTILE MOTION**

Vertical projectile motion refers to objects moving up or down perpendicular to the ground.



1

### VERTICAL PROJECTILE MOTION

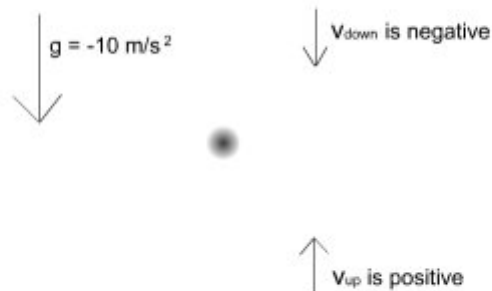
Be careful of text books telling you to always use  $g$  positive for downward motion and negative for upward.

The sign of  $g$  does not change if an object is moving up and down in the same problem. The acceleration is always downward towards the centre of earth.

Choose the sign for the upward direction and stick to it. All vectors pointing upward would then have this sign and all vectors pointing downward would have the opposite sign. <sup>2</sup>

### VERTICAL PROJECTILE MOTION

Let's choose upward to be positive in the following example.



3

### VERTICAL PROJECTILE MOTION

An object is projected upward at 30 m/s. Calculate the time at which its displacement will be 40 m above the ground.

We will solve this problem twice. The first time we will choose upward to be positive and the second time downward will be positive.

4

**VERTICAL PROJECTILE MOTION**

Choose upward as positive.

$$u = 30 \text{ m/s}$$

$$g = -10 \text{ m/s}^2$$

$$s = 40 \text{ m}$$

$$t = ?$$

5

**VERTICAL PROJECTILE MOTION**

$$s = ut + \frac{1}{2}at^2$$

$$40 = 30t + \frac{1}{2}(-10)t^2$$

$$t^2 - 6t + 8 = 0$$

$$(t-4)(t-2) = 0$$

$$t = 2 \text{ s or } 4 \text{ s}$$

6

**VERTICAL PROJECTILE MOTION**

Choose upward as negative.

$$u = -30 \text{ m/s}$$

$$g = 10 \text{ m/s}^2$$

$$s = -40 \text{ m}$$

$$t = ?$$

7

**VERTICAL PROJECTILE MOTION**

$$s = ut + \frac{1}{2}at^2$$

$$-40 = -30t + \frac{1}{2}10t^2$$

$$t^2 - 6t + 8 = 0$$

$$(t-4)(t-2) = 0$$

$$t = 2 \text{ s or } 4 \text{ s}$$

8

**Questions**

1. A ball is being thrown upward. What is the value of its acceleration when it reaches its highest point?
2. If a ball is moving upward and  $g = -10\text{m/s}^2$ , what is the sign of the velocity while the ball is going up?
3. What is the sign of the displacement at any time before the ball hits the ground?





## MOMENTUM

### MOMENTUM

At the end of this section you will be able to:

1. know the relationship between impulse and momentum; ( 1 )
2. know and calculate change in momentum; ( 1 2 3 )
3. know and apply the conservation of linear momentum; ( 1 2 3 )
4. know the difference between elastic and inelastic collisions. ( 1 )

### IMPULSE AND MOMENTUM

According to Newton II:  $F = ma$

$$F = m \frac{\Delta v}{\Delta t}$$

Therefore:  $F \Delta t = m \Delta v$

**Impulse**

**Change in Momentum**

1

### CHANGE IN MOMENTUM

$$\begin{aligned} \Delta p &= m \Delta v \\ &= m(v - u) \\ &= mv - mu \\ &= \text{momentum now} - \text{momentum previous} \end{aligned}$$

Change in momentum is a vector and therefore has direction. This direction is indicated by the sign of the answer. The following example illustrates this.

1

## CHANGE IN MOMENTUM

Imagine a ball being bounced off a wall.  
Choose motion towards the right as positive.



$$V_1 = 3\text{m/s}$$

$$\text{contact time} = 0,003\text{ s}$$

$$V_2 = -2\text{m/s}$$

$$\text{mass of ball} = 100\text{ g}$$

$$\begin{aligned}\Delta p &= m\Delta v \\ &= 0,1(-2-3) \\ &= -0,5\text{ kgm/s}\end{aligned}$$

2

## CHANGE IN MOMENTUM

$$\begin{aligned}F\Delta t &= F \times 0,003 \\ F \times 0,003 &= -0,5 \quad (\text{equal to } m\Delta v) \\ F &= -166,67\text{N}\end{aligned}$$

This example shows that the change in momentum and the force responsible for that change has the same sign and therefore the same direction. Compare Newton II.

3

### Questions

1. What is impulse?
2. How is change in momentum calculated?
3. Is change of momentum a vector or a scalar?

## CONSERVATION OF MOMENTUM

*The total linear momentum of an isolated system remains constant in magnitude and direction.*

This means that the vector sum of the momenta of all the parts in an isolated system before a collision or explosion, is equal to the vector sum of all the momenta of all the parts after the collision or explosion.

1

### CONSERVATION OF MOMENTUM

A = 700g		B = 500g	
A		B	
Velocity	-0,5 m/s	Velocity	1,5 m/s
Momentum	-0,35 kgm/s	Momentum	0,75 kgm/s

The animation above shows us how the velocities and momenta of the two trollies change during collision. Note that the total momentum stays constant. The next example shows how to do a calculation. 2

### CONSERVATION OF MOMENTUM

Trolley A of 700g and trolley B of 500g move towards each other at 2 m/s. Calculate the final velocity of trolley A if trolley B moves backward at 1m/s after the collision. Take trolley A's initial direction to be positive.

$$\begin{aligned}
 p_{\text{before}} &= p_{\text{after}} \\
 m_1 u_1 + m_2 u_2 &= m_1 v_1 + m_2 v_2 \\
 0,7 \times 2 + 0,5 \times (-2) &= 0,7 v_1 + 0,5 \times (1) \\
 v_1 &= -0,14 \text{ m/s}
 \end{aligned}$$

3

### ELASTIC AND INELASTIC COLLISIONS

In an elastic collision kinetic energy and momentum are conserved. In an inelastic collision, momentum is conserved, but not kinetic energy.

The conservation of kinetic energy is determined by calculating the total kinetic energy of all parts before the collision and comparing that to the total kinetic energy of all parts after the collision.

1

**Questions**

1. What is meant by the conservation of linear momentum?
2. What is meant by an elastic collision?
3. If linear momentum is conserved in a system, does that mean that each object in the system has a constant momentum that can never change?



## WORK, ENERGY, POWER

### WORK, ENERGY, POWER

At the end of this section you will be able to:

1. know how work is defined and how to calculate it; ( 1 2 3 )
2. know the energy concept and apply the conservation laws of energy; ( 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 )
3. know how to calculate power. ( 1 )

### WORK

Work is done on an object when a force exerted on the object, moves it in the direction of the force.

$$w = F \times s$$

Work is a scalar quantity.

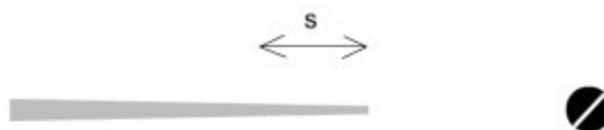
1 Joule is the work performed when a force of 1N works over a distance of 1m.

1. The force must act on the object all the time.
2. There must be resistance of some kind.
3. Displacement must be in the direction of the force.

1

### WORK

Let's look at a billiard ball being struck by a cue. The work done against friction between the ball and the table is neglected in this example.



No work is performed after the cue has broken contact with the ball. The ball moves on, due to its own inertia and momentum.

2

## WORK

Consider a crate being pulled by a force making an angle with the horizontal.



No work is done in the vertical direction as the crate is not lifted. The work performed is equal to  $F \cos \theta$  times the distance over which the crate was moved. <sup>3</sup>

### Questions

1. When does a force perform work?
2. How is work calculated?
3. When there is no resultant force acting on an object, but it keeps on moving, what is keeping it moving?

## ENERGY

Energy is the ability to do work. When work is done, energy is transferred to another form or place.

Potential Energy: *The energy an object has by virtue of its position or state.*



1

## ENERGY

The previous animation is an example of gravitational potential energy.

Potential energy = work done to lift it

$$E_p = F \times h \\ = mgh$$

The formula only applies to small changes in height as the value of  $g$  would decrease with an increase in distance from earth. We don't <sup>2</sup> usually work with such extreme cases.

## ENERGY

Kinetic Energy is the energy an object has because of its motion.

Consider an object that moves from rest.

$$\begin{aligned}v^2 &= u^2 + 2as \\ &= 2as \quad (u=0) \\ a &= \frac{v^2}{2s}\end{aligned}$$

3

## ENERGY

Substitute  $a = \frac{v^2}{2s}$  in  $F = ma$ .

$$F = \frac{mv^2}{2s}$$

Kinetic Energy gained = work done on the car

$$\begin{aligned}E_k &= \frac{mv^2}{2s} \times s \\ &= \frac{1}{2}mv^2\end{aligned}$$

4

## ENERGY

There are two main forms of energy:

Kinetic Energy

Potential Energy

We can distinguish between the following types of Potential Energy.

mechanical; electrical; heat;  
light; chemical; nuclear; matter

5

# ENERGY

Conservation of energy:

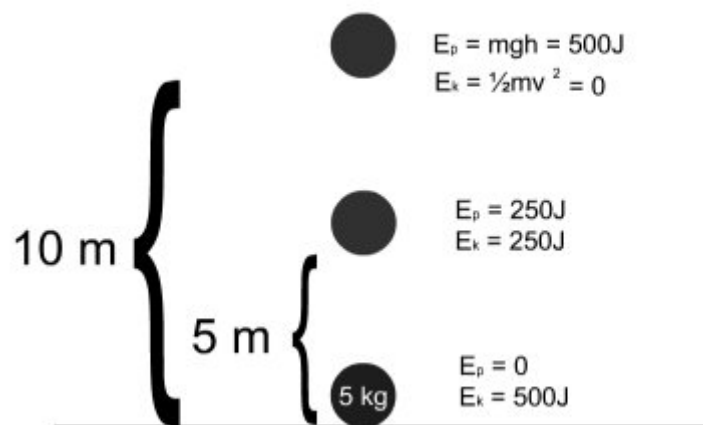
*Energy cannot be created or destroyed, but one form of energy can be transformed into an equivalent amount of another form.*

Conservation of Mechanical Energy:

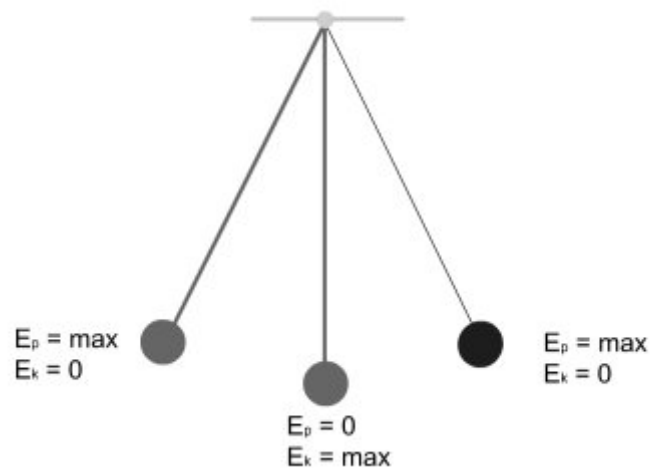
*The sum of the gravitational potential energy and the kinetic energy remains constant during free fall.*

The following two animations illustrate the conservation of mechanical energy. <sup>6</sup>

# ENERGY



# ENERGY





## ENERGY

The following example shows how to use both conservation of momentum and conservation of mechanical energy in the same problem.



Show that the recoil of the gun (i.e. its backward velocity) can be calculated if the following is known: Mass of the gun, mass of the block, mass of the bullet, the height through which the block swings up and the gravitational acceleration.

9

## ENERGY

To solve this problem we will make use of the following notation.

$m_g$  = mass of gun

$m_b$  = mass of bullet

$m_{b+bl}$  = mass of bullet + block

$v_g$  = velocity of gun (recoil)

$v_b$  = velocity of bullet

$v_{b+bl}$  = velocity of bullet + block

10

## ENERGY

When the explosion between the bullet and the gun takes place, momentum for the system is conserved. Take direction of the bullet as +.

$$-m_g v_g = m_b v_b$$

$$v_g = \frac{-m_b}{m_g} v_b$$

11

## ENERGY

When the collision between the bullet and the block takes place, momentum is conserved.

$$m_b v_b = m_{b+bl} v_{b+bl}$$

$$v_b = \frac{m_{b+bl}}{m_b} v_{b+bl}$$

12

## ENERGY

Substitute  $v_b = \frac{m_{b+bl}}{m_b} v_{b+bl}$  into  $v_g = \frac{-m_b}{m_g} v_b$

$$v_g = \frac{-m_b}{m_g} \times \frac{m_{b+bl}}{m_b} \times v_{b+bl}$$

$$v_g = \frac{-m_{b+bl}}{m_g} \times v_{b+bl}$$

13

## ENERGY

The potential energy of the bullet-block combination at the top is equal to the kinetic energy of the combination at the bottom.

$$\frac{1}{2} m_{b+bl} v_{b+bl}^2 = m_{b+bl} gh$$

$$\therefore v_{b+bl}^2 = \frac{2m_{b+bl} gh}{m_{b+bl}}$$

$$v_{b+bl} = \sqrt{2gh}$$

14

## ENERGY

Substitute  $v_{b+bl} = \sqrt{2gh}$  into  $v_g = \frac{-m_{b+bl}}{m_g} \times v_{b+bl}$

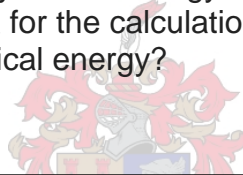
$$v_g = \frac{-m_{b+bl}}{m_g} \times \sqrt{2gh}$$

This equation proves that the recoil of the gun can be determined by knowing only the masses of the gun, bullet and block, as well as the height through which the block swings and the gravitational acceleration.

15

### Questions

1. How are work and energy related?
2. What is meant by kinetic energy?
3. Derive a formula for the calculation of kinetic energy.
4. What is mechanical energy?



## POWER

Power is the rate at which energy is transferred.

1 Watt is the power delivered when 1 Joule of work is done in 1 second.

$$P = \frac{W}{t}$$

Therefore:  $w = Pt$

1

### Questions

1. What is power?
2. How is power calculated?
3. What is the unit of measurement for power?